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BRIDGE RATING AND ANALYSIS STRUCTURAL SYSTEM (BRASS)

Vol. I. System Reference Manual

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September 1973
Final Report

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16. Abstract
State bridge engineers are required by the 1971 National Bridge Inspection Standards to determine the safe load carrying capacity for each highway bridge in his State. In addition, he is required to determine a structural rating for each bridge. This report describes a computerized Bridge Rating and Analysis Structural System (BRASS), developed by the Wyoming Highway Department, which can be used by bridge engineers as a tool in making these determinations.

This report is the first volume in a series of three volumes. The titles of the three volumes are: I, System Reference Manual; II, Example Problems; and III, Programming Aids.

The material in this volume lists and describes the components of the System which include Bridge Design, Structural Inventory, Deck Design and Review, Structural Analysis, Structural Loading, and Girder Section Design and Review. The System consists of a set of 45 computer programs which are flexible and user oriented. The bridge design processes included in these programs adhere to uniform bridge design standards. The programs will work for any State highway organization. This volume, Volume I, describes in detail the coding of highway bridge structural and loading data for processing by the System's computer programs.

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PREFACE

On April 27, 1971, the National Bridge Inspection Standards were presented to all states. These standards require a bridge rating to determine the safe load carrying capacity for each bridge in the nation. We in the State of Wyoming felt that it would be a monumental task to rate the approximately 2,000 bridges in our state by hand. We, therefore, felt that we had to look to a computer system for help.

We had originally visualized and charted our Bridge Design System in 1966. At that time, programming of the system, consisting of two basic subsystems, Structural Analysis and the Structural Loading, was begun. By April, 1971, the system was nearly self-sufficient and many of the bridges that must be rated had been designed by the system.

In addition, the original plan had included an Overload and Section Design subsystem. But by 1971, development of this subsystem had not yet been started.

Upon completing cost studies for the rating of our bridges by manual methods and for the expansion of our Bridge Design System, we found it feasible to expand the system to determine our bridge ratings.

ACKNOWLEDGEMENT

The authors of this manual wish to express their appreciation in this accomplishment for the cooperation received from the United States Department of Transportation, Federal Highway Administration. The opinions, findings and conclusions expressed in this publication are those of the Wyoming Highway Department and not necessarily those of the Federal Highway Administration.

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1. GENERAL INFORMATION

1.1 Scope. This system has been developed so that a designer or user may design, review or load rate structures. For example, in the design phase of a concrete structure, the user would make a preliminary layout of his structure and ask the computer to give him the amount of steel in the concrete sections that is required and the actual stresses in all parts of the section that is critical. In the review and rating phase, the user would code the data from "as constructed" plans and inspection reports.

This system will also design, review and load rate transversely reinforced concrete deck slabs and timber decks.

The loading component of the system allows dead loads and live loads. The live loads consist of what are commonly called lane loads in the AASHO manual and the HS truck. The HS truck has three axles with variable spacing between the second and last axle. The live loading may also consist of from one to 24 wheel loads at selected spacings. All live loads may be applied to the structure in a directional manner; that is, the user may have trucks going in one direction, ahead station for instance, or have them going in both directions. This facilitates load rating structures that have single direction traffic.

The section design component of the system has been combined to handle steel girders, concrete girders, concrete slabs, timber beams, and composite concrete-steel girders. The steel sections are always assumed to be broken into parts. This means that when a wide flange girder or built-up steel girder bridge is to be designed or rated, one must enter dimensions of the flange, the web and the fillets, as required.

The analysis component handles rigid frames one story in height with as many as seven legs. It will handle continuous structures with from one to 19 spans and slant leg structures with three through five spans. Rigid frame analysis allows no sidesway or settlement of any joints. The slant leg analysis allows sidesway of all upper joints and settlement of any upper joint into which the leg frames. Cantilever spans, hinges or pin connections are not allowed.

The load rating portion of the section analysis component load rates on shears, flexural stresses and bearing stresses. The bearing stresses govern only at the ends of the member. These load ratings may be controlled by the user entering those allowable stresses that he wishes. For example, if at the 1.0 point, a person did not want to load rate on bearing stresses, he need just omit the allowable stress in bearing. In composite sections the user may load rate all allowable shears between composite concrete and the steel girder by simply entering in the amount of shear allowed in that region, i.e., shear developed by shear connectors, welds, etc. A natural outcome of this is that if one wants to design for the shear in a weld section between flanges and web, he just needs to place an allowable shear stress in the weld.

The inventory component, as mentioned herein, is not included in the system.

1.2 System Concepts. The system concepts as displayed in Figure 1, entitled, "Bridge Design Subsystem", are that of separate components

BRIDGE DESIGN SUBSYSTEM

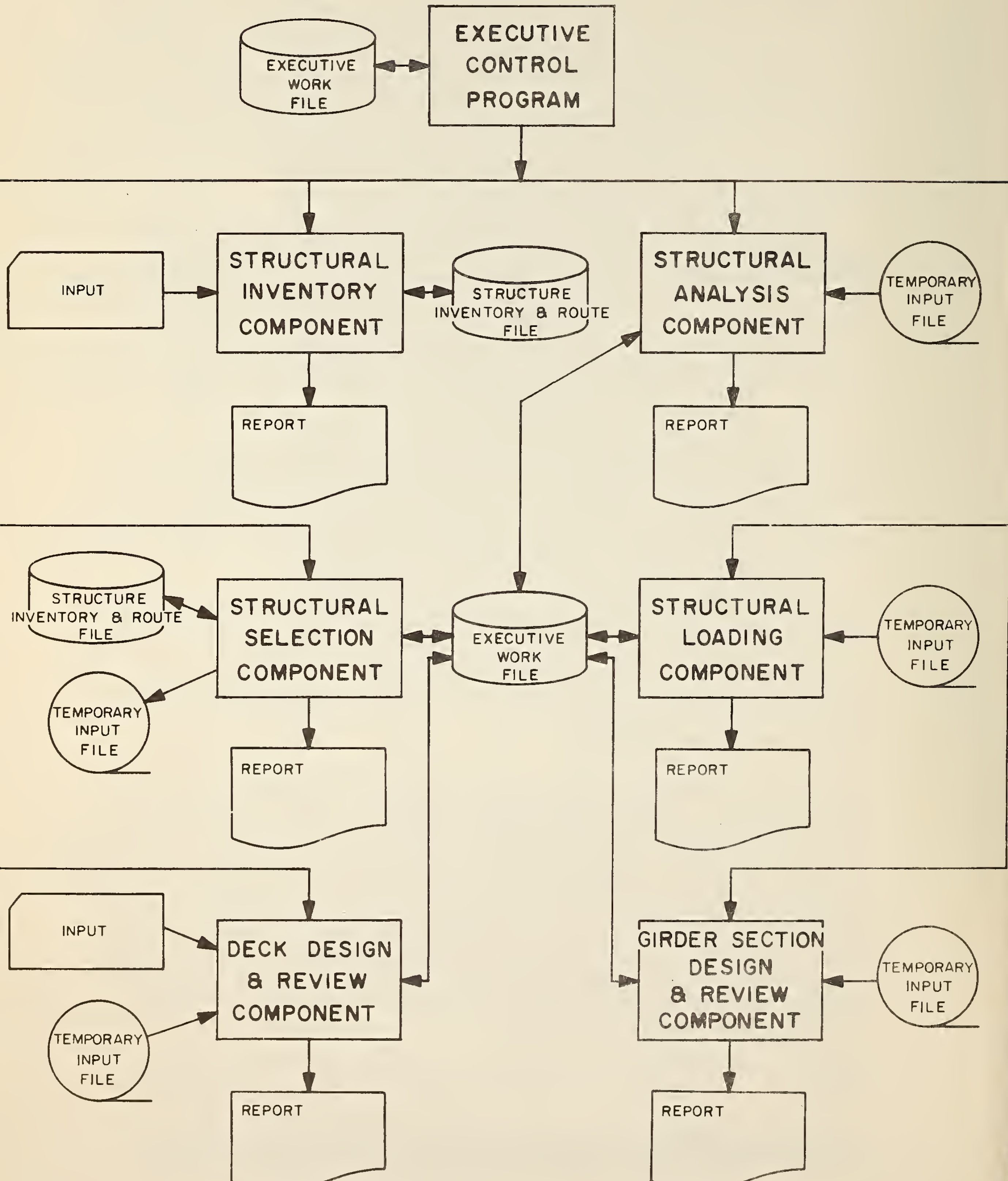


FIGURE 1

being related by a program that is called the executive control. The executive control has the duty of determining what the next job is that should be done. The input cards, called control cards, coded by the user call the first program in the series. Data cards following control cards determine the phases to follow in a given component.

Components are a group of programs that perform a single and specific job. These jobs generally break down into categories of work. The inventory component (Figure 2) indicates that it has the job of building an inventory file and maintaining it. The inventory file contains a route file, consisting of a route, a section of that route, mileposts at which structures are located, and the number of structures at each location. The route file identifies the structure on the main file. The main file carries all data related to that structure. No structure is entered in the file more than once, except in the route portion of the file. The data that is on the inventory file consists of all items currently required by the Federal Highway Administration in its bridge inventory. Also maintained on file, are inspection data, which describe the condition of a structure so that it may be down rated if in poor condition.

The deck design and review component (Figure 3) reviews, designs or rates the decks of bridges. The decks may be continuous over girders or simple spans with cantilever edges. In order for a user to design a concrete deck, it is only necessary for him to omit the amount of steel required in tension regions of the deck. The designer may obtain the ratings by filling out a request in the input.

The structural analysis component (Figure 4) develops influence lines for moments, shears and reactions for each point on the structure that the designer has requested. These influence lines are stored on the direct access file denoted as the executive work file. The executive work file will be built by each component with all data that will be required by subsequent components. This component also has the task of developing all dimensions for each section of the beam. These dimensions consist of flange thicknesses and widths, web depths and thicknesses, fillet dimensions, composite slab dimensions, etc.

The structural loading component (Figure 5) searches out each influence line and applies the dead load to it as requested and then applies each of the live loads that the user wants. There may be three live loads on any given run. These live loads may be any combination of the aforementioned loading types. The live loading portion develops what is called an action matrix. This matrix consists of shears, moments, axial and reaction actions. The diagonal of this matrix is the maximum value for that loading condition. The other elements of that column are the other actions, with the live load in the position that created the maximum in the diagonal element. Therefore, when load rating a section, one may find an axial load and its corresponding flexural stresses for similar loadings.

This component also has the task of developing influence lines for deflections. The reason for this not being in the analysis portion is that the user needs to develop an influence line for a unit load crossing a span in his deflection calculations. Then, if so requested, the component will develop deflections. These deflections are for both dead load and live load.

STRUCTURAL INVENTORY COMPONENT

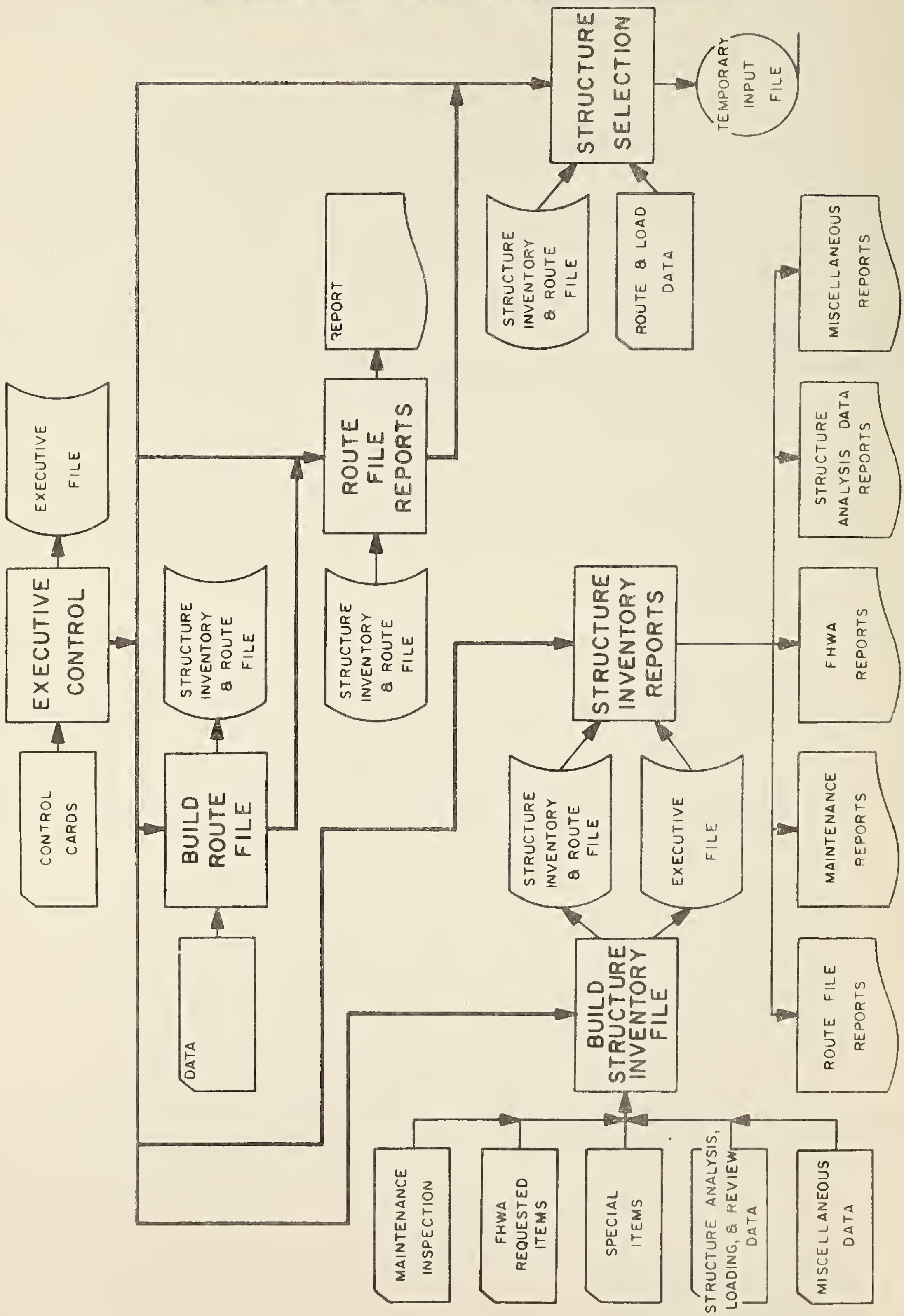


FIGURE 2

DECK DESIGN & REVIEW COMPONENT

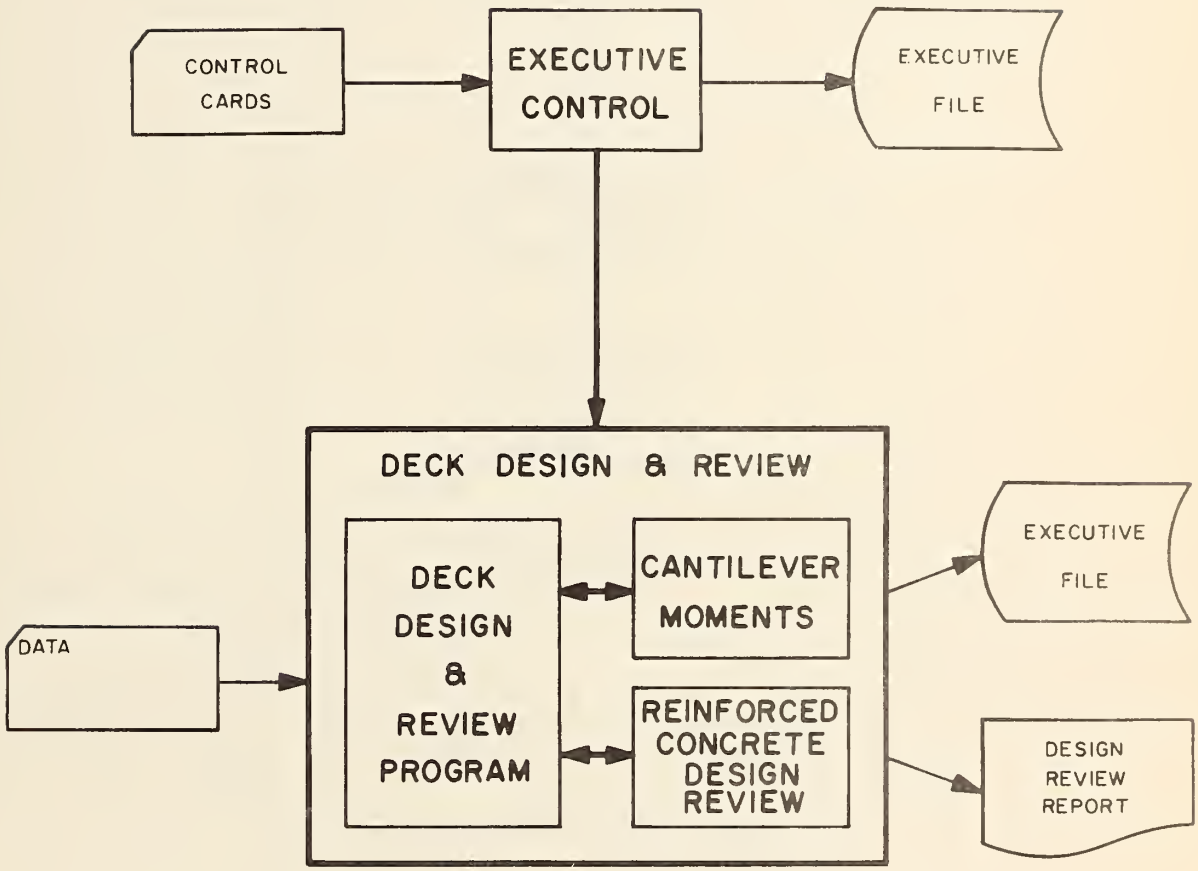


FIGURE 3

STRUCTURAL ANALYSIS COMPONENT

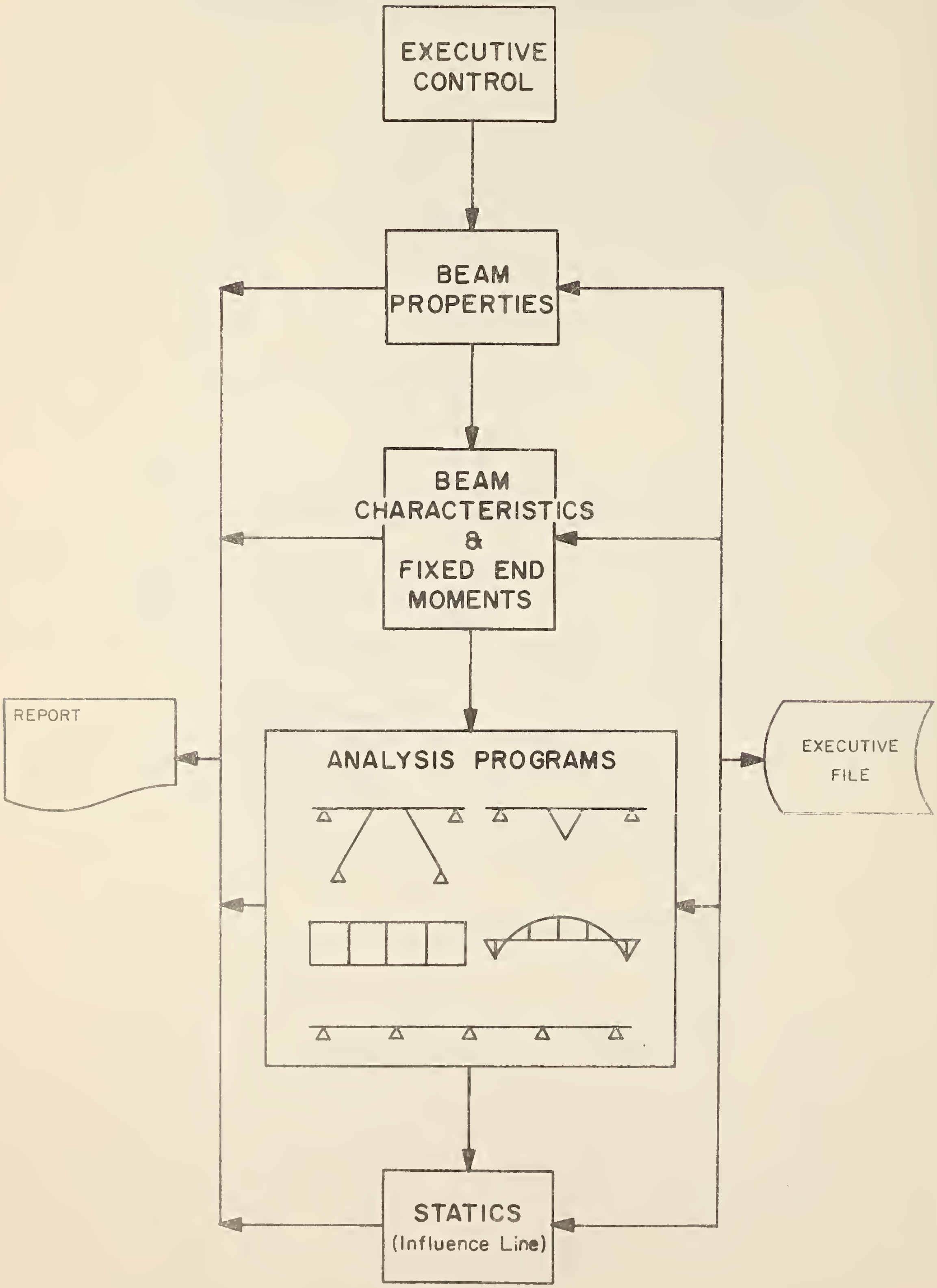


FIGURE 4

STRUCTURAL LOADING COMPONENT

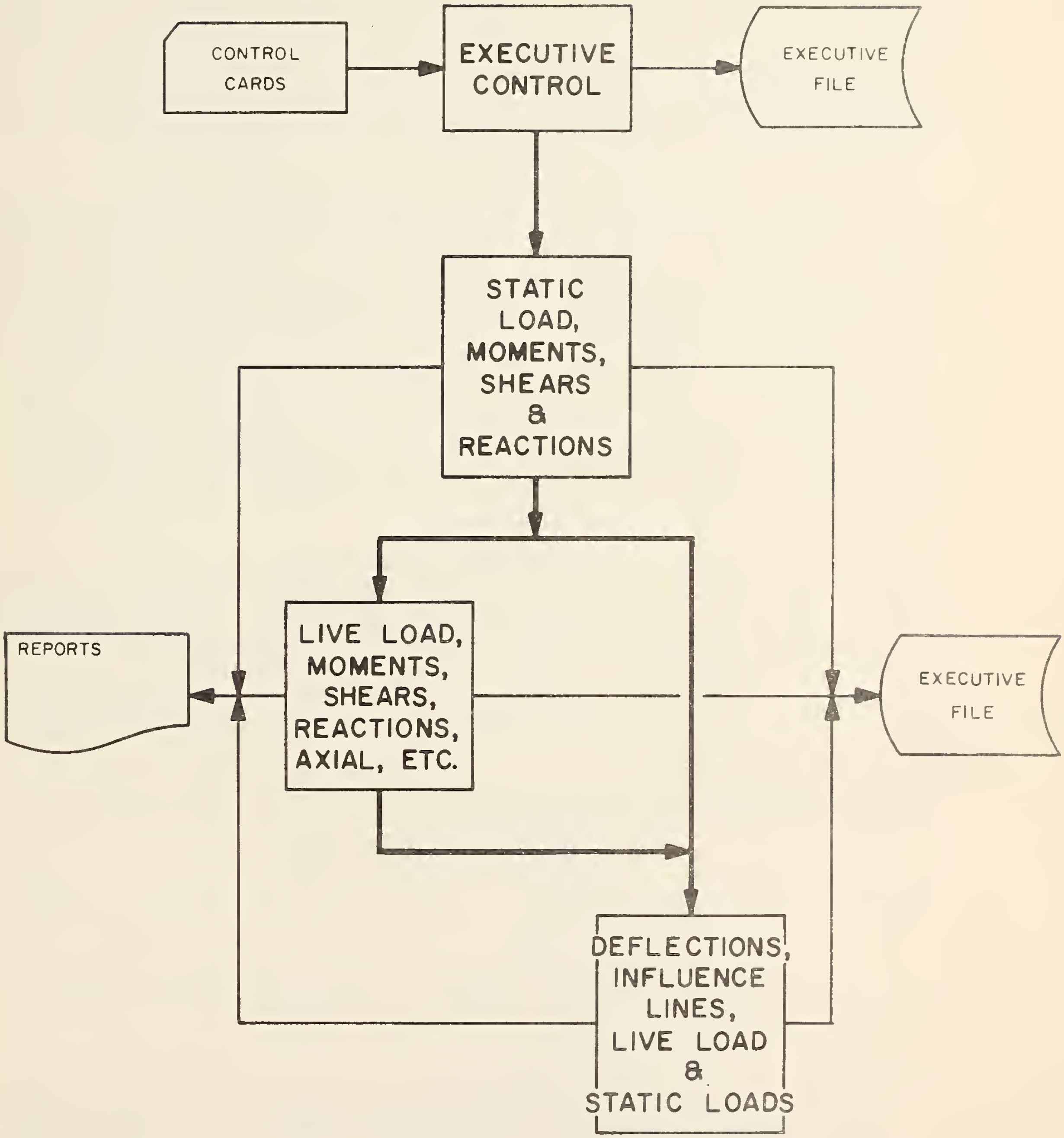


FIGURE 5

The girder section design and review component (Figure 6) reads in the dimensional data developed by the analysis component program, the matrix developed by the load rating program, and other data necessary from cards coded by the user. From this data, allowable stresses and actual stresses are developed and stored on the direct access file. If requested by the user, the data is used in the calculation of load rating factors. The load rating factors are numbers which indicate the intensities of live loads that may be applied to this structure within the limits that have been coded. That is, the actual stress will be equal to the allowable stress if this intensity is applied.

In composite section design, a person codes a run for dead load using a steel section as the structural element and then applying the dead load which would be on the structure. The dead load, of course, would be the unit weight of the material of the girder, the weight of the forms, and the weight of the concrete that will be placed. If there is a live load that must be applied at this time, such as screeding equipment, etc., it may be placed in this dead load run. Of course, this would never be the case when strictly rating a structure. Next, the user must code a live load run which would be in the job stream immediately following the dead load run. Now the section will be the composite section with no dead load, except superimposed dead load, consisting of surfacing, curbs, etc. Then the live loadings would be coded so that ratings may be made for each.

There is a relationship between what is referred to as truck no. 1 in the deck design portion and truck no. 1 in the girder design portion; i.e., they must be identical. Load ratings are calculated for each corresponding truck and the summary sheet will indicate the smallest load factor, and where it is in the deck or in the girder. The summary sheet indicates the governing load factor, the position of the factor (deck or girder), and the type of stress, such as a shear, flexure stress or bearing.

1.3 <u>Programming Information.</u> The programs are coded for the IBM 360 Model 40 computer, utilizing a storage capacity of 72,000 Bytes. All programming has been done using Fortran IV language.

Programming controls for design or review of a structure were established and consist of the following:

a. The engineer must have full control over output desired. That is, by coding, he should be able to obtain intermediate output, along with final results. This concept enables the engineer to check all steps in a design.

b. The system should be flexible enough to allow incorporation of any type of future structural analysis. Types of structures that the system is capable of analyzing are described in the description of input, Structural Analysis.

c. The flexibility of the system must be such that a complete design would be possible with one run of the system. This means that any parameters calculated in the program must be stored on a file for use by any future program as input. It should be possible to analyze the girders by the analysis portion, load the girders with the load

GIRDER SECTION DESIGN & REVIEW COMPONENT

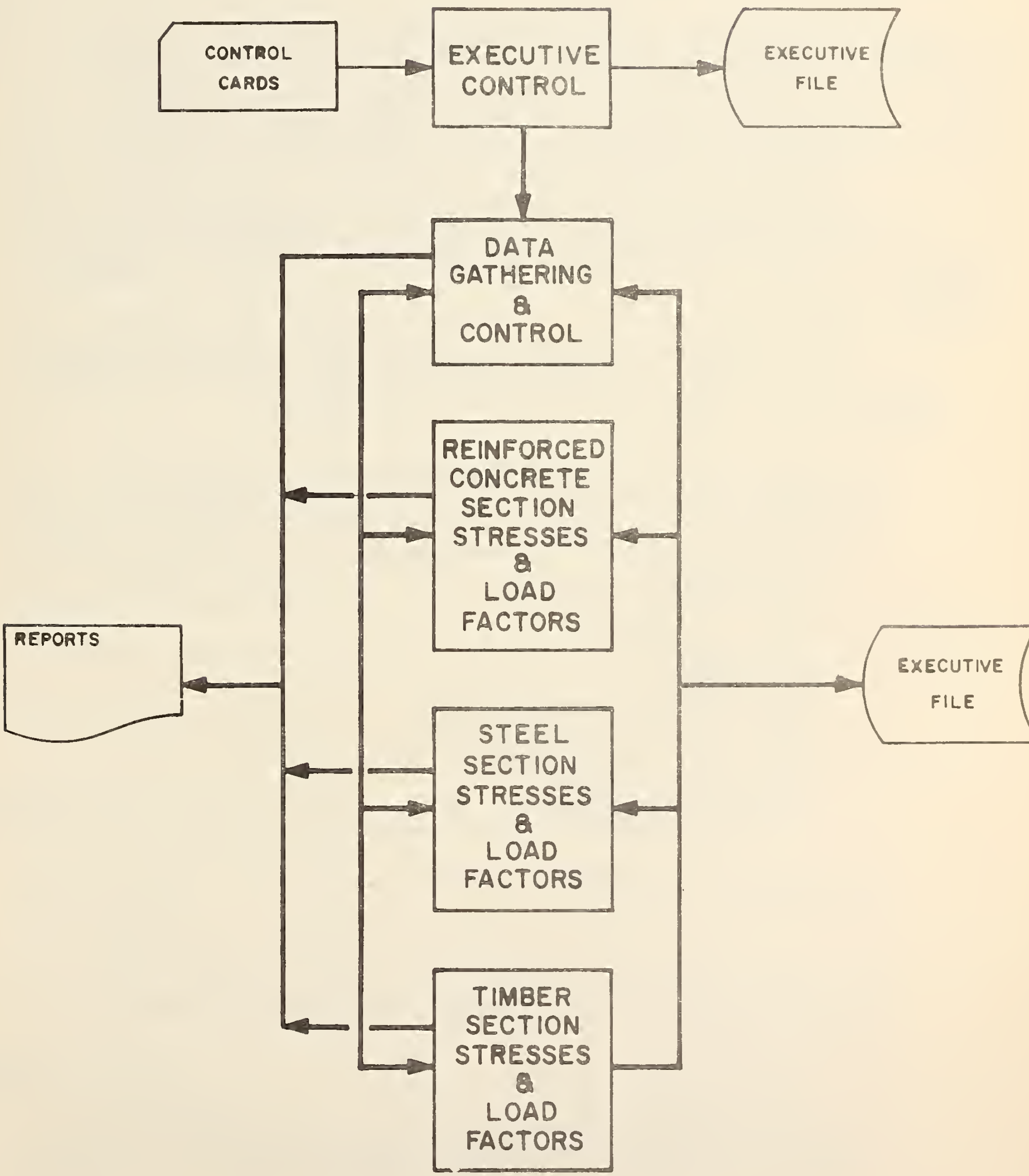


FIGURE 6

routines, design (or review) the sections with the design routines, etc., (getting the desired output from each component) all in one run.

d. The designer should find the input to be straightforward and logical. To implement this, one form was decided upon and all input is entered in this format.

1.4 System Components. The parts of the system that deal with a logical phase of the work have been designated as components. The components are shown in the rectangular blocks in Figure 1. Figure 2, "Structural Inventory Component", is included in the text to depict the position of the structure inventory editing and the structure inventory and route files within the administrative component.

The four components that are pertinent in obtaining a review and rating of a bridge structure will be developed. These are: "Structural Analysis Component" (Figure 4), "Structural Loading Component" (Figure 5), "Girder Section Design and Review Component" (Figure 6), and "Deck Design and Review Component" (Figure 3).

a. Structural Analysis Component. Each component is made up of blocks which represent a class of work to be done. These blocks are called applications, of which there are four in this component.

(1) Beam Properties. This program develops all properties of a section at each 1/20 point of the span. These properties include:

Beam depth
Cross-sectional area
Moment of inertia
Distance to centroid of area
Width of web
Flange thickness of top flange
Flange thickness of bottom flange
Flange width of top flange
Flange width of bottom flange
Composite slab dimensions
Cover plate dimensions

The span ratio and method of depth variation are also given for each span.

(2) Beam Characteristics and Fixed End Moments. This program determines the relative stiffness and carryover factors for each end of each span. It then determines the fixed end moments for a unit load at each tenth point of each span and for a uniform load on each span.

(3) Indeterminate Coefficients (Analysis). This program sets up the equations for indeterminacy and inverts the matrix of constant coefficients. The inverted matrix is used by successive programs to determine influence line coefficients.

(4) Influence Lines (Statics). This series applies loads to each tenth point of each span and finds the shears at each end of each span and calculates the moments at each tenth point (including ends of spans) of each span. The areas are then calculated for each influence line.

All coefficients are relative to the first span length, making use of the lines easy.

Structure Type (Main Members). Currently, the types of structures that can be analyzed are divided into six groups. The groups include:

(1) The "basic structure" (Figure 41), is a cell type layout one story in height with from one to six cells. Most bridge structures can be designed using the members within this layout. Any member may be excluded, with the exception of member number one, thereby giving many variations. The structures allow no sidesway in the analysis. The structures may be thought of as piers in elevation, box girder sections, or any other structure with this basic configuration.

(2) Continuous beam bridges with from one to nineteen spans. The "continuous type layout" (Cell type = 9), is to be used when there are more than six continuous spans (Figure 43).

(3) Rigid frame structures with from one to six spans.

(4) Slant leg and cant leg structures with from three to five spans. The legs may cant in any direction, thereby giving results for slant leg and so-called delta bent structures. The "slant leg layout" (Figure 42), allows sidesway and settlements of joints C, E, G, and I. Various other structures may be designed by omitting different spans.

(5) Rigid frame box culverts with from one to six cells.

(6) Simple span structures.

(7) No hinges or cantilever spans are allowed.

Structure Type (Secondary Members). The types of members that can be analyzed are divided into three groups:

(1) Continuous or simple span slabs, designed one way only, and timber decking.

(2) Continuous or simple span slab supports.

(3) Continuous or simple span floor beams.

Section and Material Types. The system is capable of analyzing the following sections:

(1) Reinforced Concrete - slabs, T-girders, box girders, circular columns, and rectangular beams or columns.

(2) Structural Steel - rolled section (composite or non-composite), welded plate (composite or non-composite), riveted girder, built-up girder, and box girder (composite or non-composite).

(3) Timber

Web Depth Variations. All members of the structures are called spans and may have almost any cross-sectional variation desired. The first variation that is thought of is the so-called depth (thickness in elevation) of the member. These possible depth variations are indicated in Figure 44 and are straight line, parabolic and break types.

Cross Section Variations. Variations in cross section are the dimensions of the separate elements, such as web thickness, flange thickness, flange width, etc. Each of these dimensions (Figure 45), may change from 20th point to 20th point of each span and is calculated on a straight line ratio.

b. Structural Loading Component. This group of programs takes the influence lines created by the "Structural Analysis" component and the loadings specified by the designer and calculates the moments, shears, reactions and deflections for each required 10th point of each span.

The loadings are of two types:

(1) The first type is static loading, where the magnitude and position of the load is entered by the designer. Static loading may be either uniform in nature or point loads.

(2) The second type of loading is the live loading, where only the magnitudes and spacings of the loads are given by the designer. Live loads consist of point loads at specified distances apart or uniform loading with a point load.

The "Structural Loading" component has three application blocks (Figure 5), consisting of:

(1) Static Load - The static load programs calculate the redundants due to the loads shown in Figure 63. The dead load of the girder is broken into a uniform portion and equivalent point loads for the non-uniform portion. The static superimposed loads consist of a uniform load for each span and up to 72 point loads on a structure.

(2) Live Load - The live loading portion of the system consists of three types.

(a) A truck with three axles where each axle has a weight specified by the designer with the distance between the first and second axle a specified fixed space; the distance between the second and third axle will vary from a minimum to a maximum as desired.

(b) A lane load with a uniform portion and one or two point loads.

(c) Truck with fixed axle spacings - alternate loading which consists of one to 24 wheel loads with spacings and magnitudes specified by the designer.

(3) Deflection influence lines for loads on the span and deflections for applied static and live loadings.

c. Girder Section Design and Review Component. After the analysis and loading routines have been executed, the system will then take the moments and shears developed by these routines and design or review the sections desired.

The "Girder Section Design and Review" component has three main application blocks (Figure 6), consisting of "Reinforced Concrete Design and Review", "Steel Section Design and Review", and "Timber Section Design and Review".

Included under the concrete applications are subroutines which analyze rectangular and circular columns. A report is generated for each of these applications which gives pertinent data concerning the section in question, such as area of steel, concrete stresses, reinforcing steel stresses, etc.

The designer has the freedom to ask for either a design or review of the member. Furthermore, he may request this design or review for every tenth point of the span, or only for those points which are critical.

The system will review and load rate a structure in the following general manner:

(1) Structural Steel

(a) A section is entered in the analysis routine (width and thickness of flange, etc.)

(b) Structure is loaded with the dead load and live load desired in the loading routine.

(c) Type of section, yield strengths of materials, and specification criteria are entered in the design and review routine.

(d) The program will calculate and print out the design stresses in the section due to moment, shear, and any added actions, such as torque and centrifugal force. Maximum transverse stiffener spacing allowed will be given for moment and shear.

Design of structural steel members is in accordance with the current AASHO Specifications and accepted design theory.

(2) Reinforced Concrete

(a) A section is entered in the analysis routine

(width and thickness of flange, etc.).

(b) Structure is loaded with the dead load and live load desired in the loading routine.

(c) Yield strengths of concrete and reinforcing steel, moduli of elasticity, clearance to reinforcing steel, etc., are entered in the design and review routine.

(d) The program will calculate and print out the design stresses in the concrete and reinforcing steel (tensile and compressive) due to moment, shear and added actions. Areas of stirrups and reinforcing steel required to resist the given loads will be printed out. Stirrup spacing required will also be printed out.

Design of reinforced concrete members is in accordance with the current AASHO Specifications and the working stress theory as presented in the "Reinforced Concrete Design Handbook, Working Stress Method", Third Edition, by the ACI.

(3) Timber - The same procedure is followed as is outlined in (1) and (2) above. The program will calculate and print out design stresses for moment, vertical shear, horizontal shear and reactions at the supports.

Structure Type (Secondary Members). The types of secondary members that can be analyzed are divided into three groups:

(1) Continuous or simple span floor beams. Floor beams may be of any section and material types as shown for main members. Loads applied to the beams can be applied as uniform or point loads, as determined by the engineer. The system will analyze and design or review the member in the same manner as for main members.

(2) Continuous or simple span slab supports. The same general criteria apply to slab supports as were enumerated for floor beams.

(3) Continuous or simple span reinforced concrete decks and timber decking. A separate routine has been included in the system for the design and review of decks. The program designs the deck in the transverse direction (perpendicular to the girders) and will design the cantilever portion of the deck, as well as the span between the girders. The loads are distributed one way only. Following is the general procedure for executing the deck design and review routine.

(a) Pertinent data pertaining to the deck section is input (thickness, girder spacing, area steel, etc.).

(b) Live load and any superimposed dead loads are input to the program.

(c) Yield strengths of materials are entered.

Load Rating. The expression "load rating" is defined as the analysis of a structure using a group of specified loads, utilizing two stress levels. The stresses must take into account the condition of the members being rated. The two stress levels used give ratings which are called Inventory and Operating.

The Inventory Rating is designed to give the load which can safely utilize a structure for an indefinite period. The Operating Rating is designed to give the absolute maximum permissible load which may utilize a structure on an infrequent basis or, in other words, it is the absolute maximum permissible stress level to which a structure may be subjected.

Load Factor (Not to be confused with term describing a design procedure). A reduction in allowable stresses for a member due to a reduced condition rating may be taken into account as an input item in the design and review routine. This is accomplished by taking a ratio of allowable stress over yield stress of the material comprising the member.

A load factor for the member in question will be calculated and printed out. This factor is multiplied by the gross weight of the truck that is being used for the rating to give both the operating and inventory ratings for that member.

The load factor for non-composite sections is determined by the equation

$$\text{Load Factor} = 1 + \frac{(F_a - f)T_{action}}{LL_{action}(f)}$$

where:

T_{action} = Total action (moment, shear)
F_a = Allowable stress given the material
f = Actual stress computed for the given applied loads
LL_{action} = Live load action (moment, shear)

This equation is expanded from the basic equation as follows:

$$\text{Load Factor} = \frac{F_a - f_{DL}}{f_{LL}}$$

$$= \frac{f_{LL} + F_a - f_{DL} - f_{LL}}{f_{LL}}$$

$$= \frac{f_{LL}}{f_{LL}} + \frac{F_a - (f_{DL} + f_{LL})}{f_{LL}}$$

Let $f_{DL} + f_{LL} = f$

Let $\frac{fI}{c} = T_{action}$ (or $vIt/Q = T_{action}$)

Let $\frac{f_{LL}I}{c} = LL_{action}$ (or $v_{LL}It/Q = LL_{action}$)

Then

$$\text{Load Factor} = 1 + \frac{(F_a - f)(f_{DL} + f_{LL})I/c}{(f_{DL} + f_{LL})f_{LL}\ I/c}$$

$$\text{Load Factor} = 1 + \frac{(F_a - f)T_{action}}{(f)LL_{action}}$$

The load factor for composite sections is determined by the equation

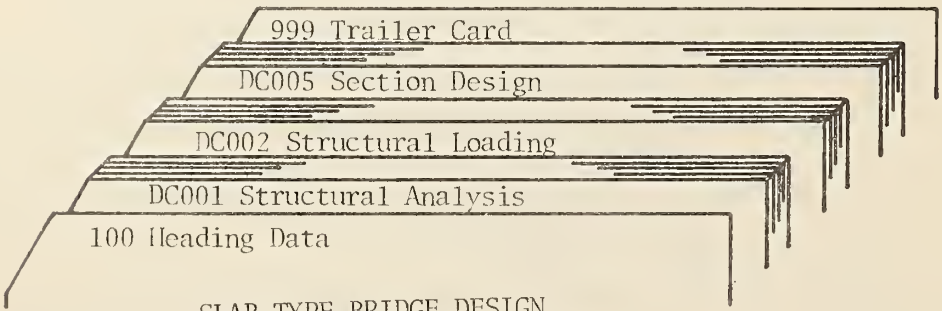
$$\text{Load Factor} = \frac{F_a - f_{DL}}{f_{LL}}$$

where:

F_a = Allowable stress given the material
f_{DL} = Dead load stress
f_{LL} = Live load stress

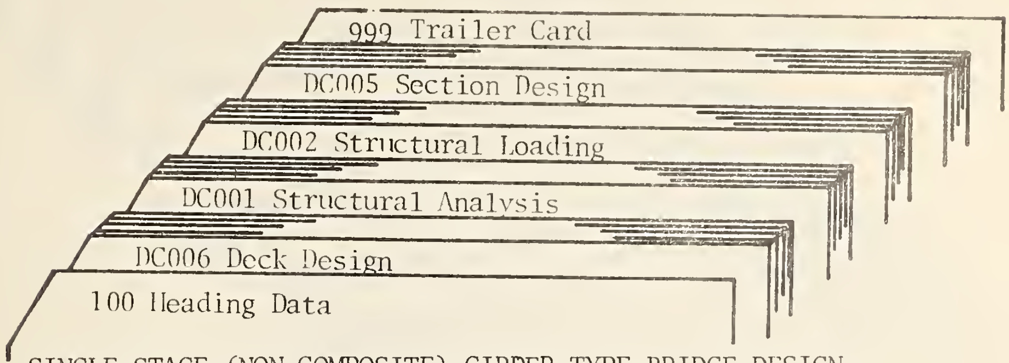
1.5 Job Card Groups. Each component of this system is initiated by a control card. In the following possible sequences, each group of data is denoted by its control card. Thus, 'DC006' coded in card columns 1 thru 5 is followed by data cards for a deck design, review or rating.

All structures do not have members reinforced perpendicular to traffic and, therefore, do not have deck design data. In this document the word "design" will have the connotation of design, review and rating, and will be understood as such. Figure 7 indicates the necessary data groups to design a slab bridge.



SLAB TYPE BRIDGE DESIGN
Figure 7

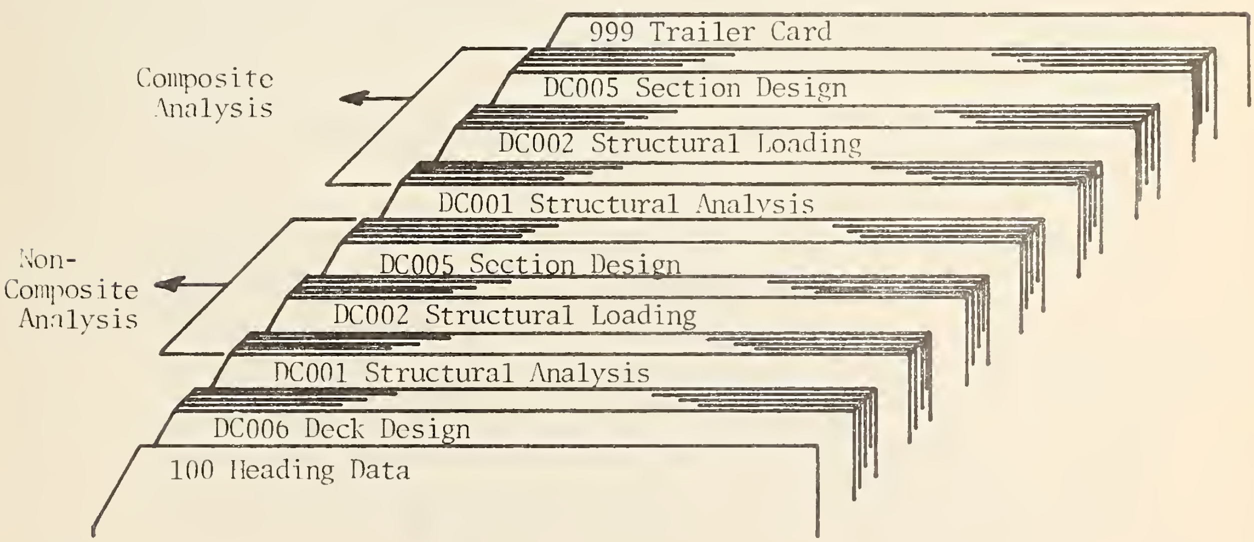
When designing a girder type bridge that is not multistage, such as a welded plate, the first data group will be the deck design. Figure 8 indicates the required data grouping to complete the problem.



SINGLE STAGE (NON-COMPOSITE) GIRDER TYPE BRIDGE DESIGN

Figure 8

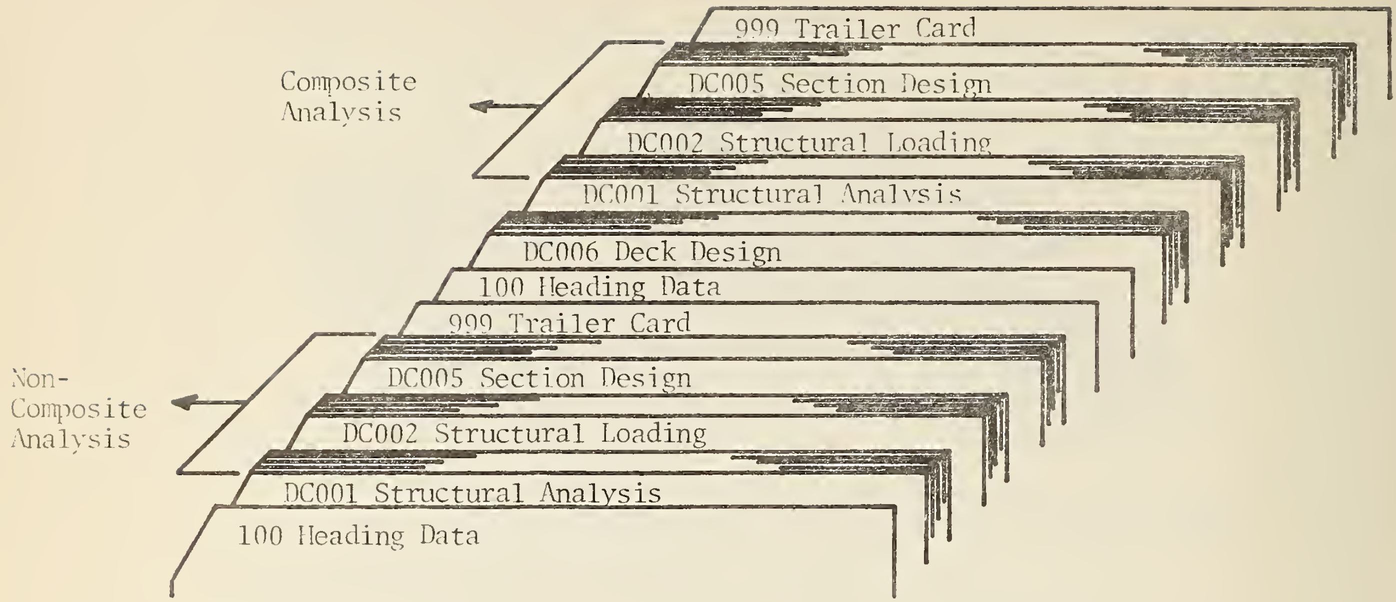
When designing a multistage girder, such as composite steel and concrete, there are two acceptable card groupings. The requirement is that the deck must be designed prior to the final design of the girder. Therefore, Figure 9 shows the deck design first and non-composite and composite sequences following. The sequence shown in Figure 10 is used when different titles are desired on the live load run.



MULTISTAGE (COMPOSITE) GIRDER TYPE BRIDGE DESIGN
Deck Input First

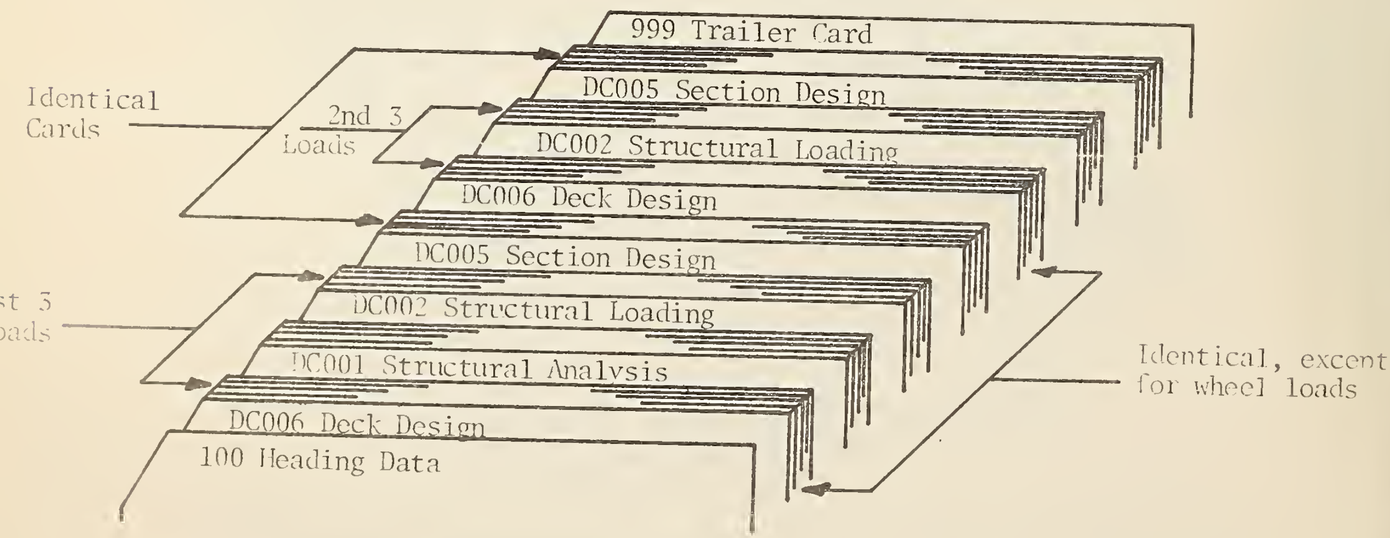
Figure 9

Figure 10 shows the deck design between the non-composite and composite analysis.



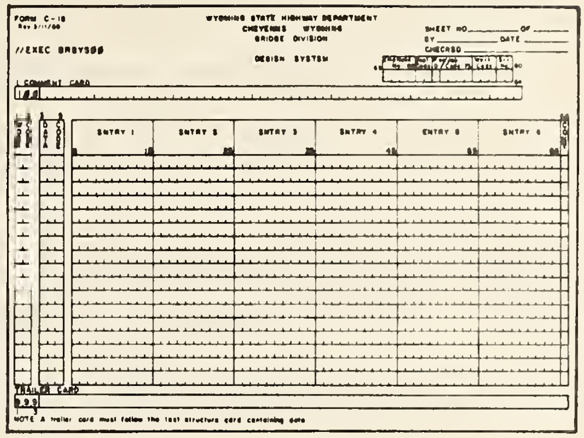
MULTISTAGE (COMPOSITE) GIRDER TYPE BRIDGE DESIGN
Deck Following Non-Composite Analysis
Figure 10

In the deck design and structural loading components, a maximum of three live loading cases is allowed in a single run. When more than three live loadings are desired, the user will have to code an extra group of cards. Figure 11 shows the necessary groups if the same maximum axle load is not used in more than one loading case. If all of the maximum wheel loads are the same, one must still code that same value for each truck on the first deck design and the second deck design may be omitted.



ANALYSIS FOR MORE THAN THREE LIVE LOADS
Figure 11

1.6 Description of Input



TYPICAL INPUT FORM
Figure 12

a. Use the Standard Bridge Program Form C-16 shown above.

b. The blank "Sheet No. ___ of ___" should be filled in each time. This allows you and everyone else (primarily keypunch operators) to know if you have as many forms as you list and if they are all there.

c. Your name, "By ____" and the date the form was filled out, "Date ____" should both be entered.

d. The blank "Checked ___" should be filled out each time. The time lost through simple mistakes, which require the program to be rerun, plus the expense in wasted computer time, make a check almost mandatory.

e. The COMMENT CARD line is intended for the designer's convenience in recording a title of pertinent information about his structure and to obtain billing information. This title and billing information will appear at the top of each page of the program output and will serve as a permanent record, both for the designer and for anyone reviewing the design in the future. An example of this type of information is shown below.

f. All input data must be entered using the "floating point" method; i.e., a decimal point must be included with each entry.

2. DECK DESIGN, REVIEW AND RATING

2.1 General Information. This component calculates actual stresses, allowable stresses and load factors for concrete and timber decks. If input for areas of required steel are omitted in concrete sections, the program will calculate the required steel areas.

This routine must be executed immediately prior to executing the girder analysis routine so that the load factors will be available on the disk for the report generator program to access.

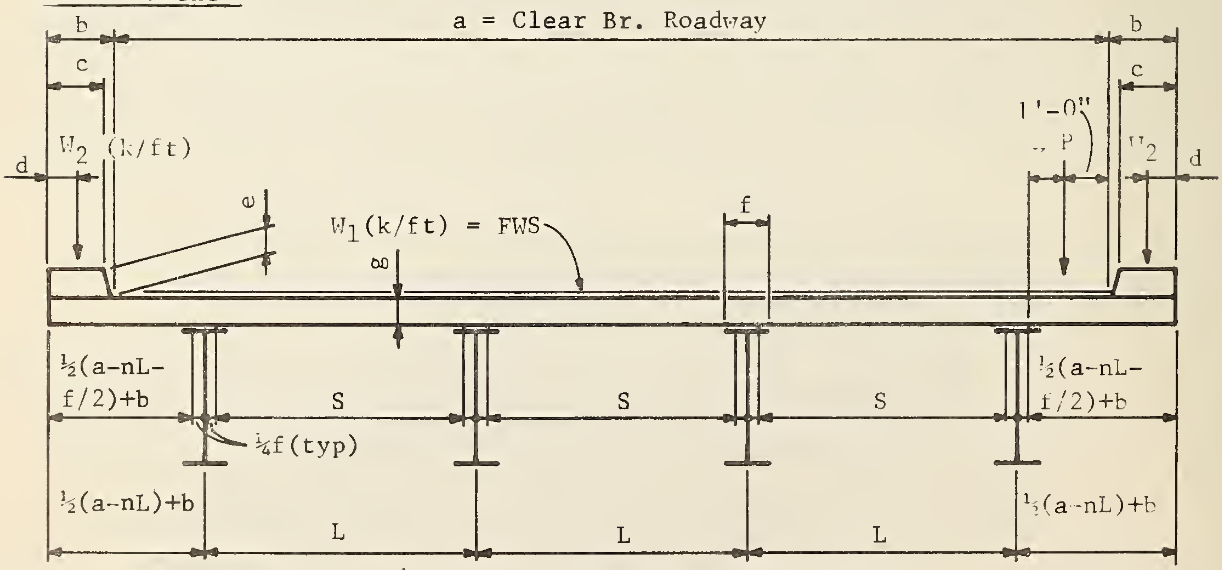
2.2 Mathematical Equations and Derivations. Following are shown the derivations for moments. The basic difference in all equations is the effective span length. (All dimensions are in feet.)

The derivations for the concrete design subroutine are found in "Reinforced Concrete Design Handbook, Working Stress Method", Third Edition, published by ACI, example 18, on page 31.

The derivations for the timber design routine are found in the American Association of State Highway Officials publication, "Standard Specifications for Highway Bridges", Tenth Edition.

STEEL GIRDER (3 or more Girder System)

Deck Moment



Exterior Girder (with a > (nL+f)), n = number of girder spaces

1) Dead Load Moment (Take M about 1/4 of top flange)

	Wt	Arm	M=Wt x Arm
Curb	$1/2(b+c)e(.150)$	$1/2(a-nL-\frac{f}{2})+1/4(3b-c)$	M_1
Slab	$g[1/2(a-nL-\frac{f}{2})+b].150$	$1/2[1/2(a-nL-\frac{f}{2})+b]$	M_2
FWS	$1/2(a-nL-\frac{f}{2})W_1$	$1/4(a-nL-\frac{f}{2})$	M_3
Rail	W_2	$1/2(a-nL-\frac{f}{2})+b-d$	M_4

$\Sigma M=M_1+M_2+M_3+M_4$

2) Live Load Moment (Cantilever M)

$$E = .8X + 3.75 = .8[1/2(a-nL-f/2)-1]+3.75=.4[a-nL-f/2]+2.95$$

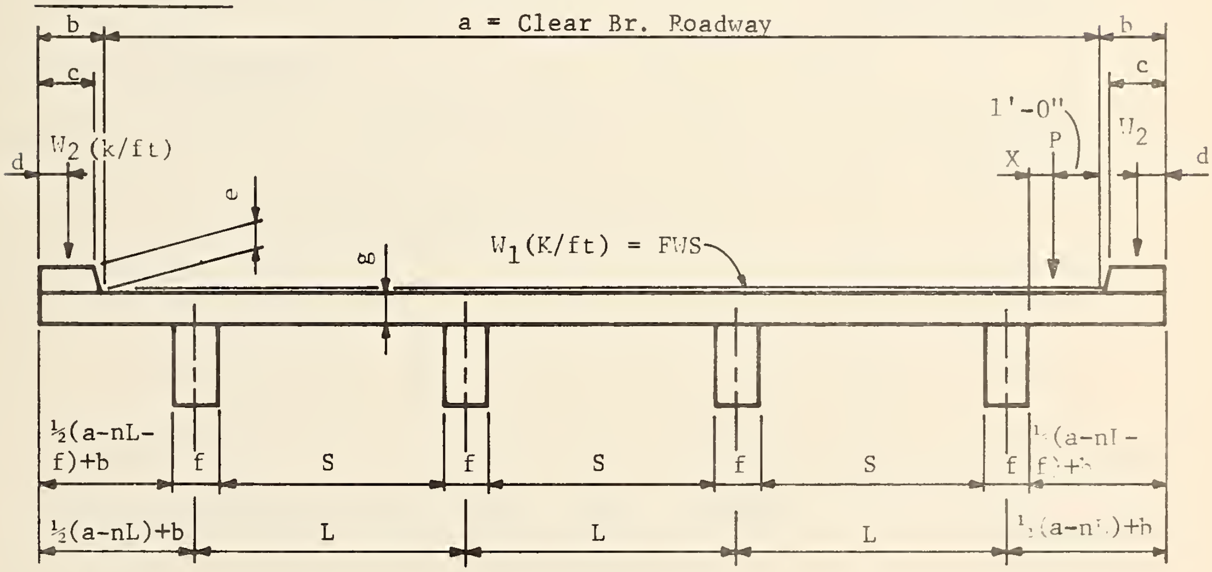
$$M = \frac{P}{E}X = \frac{P(1+I)}{.4[a-nL-f/2]+2.95}[1/2(a-nL-f/2)-1]$$

Where $P_{20} = 16^K$, $P_{15} = 12^K$, $P_{10} = 8^K$

1) + 2) = Cantilever M

T-GIRDER (3 or more Girder System)

Deck Moment



Exterior Girder (with a > (nL+f)), n = number of girder spaces

1) Dead Load Moment (Take M about outside face of web)

	Wt	Arm	M=WtXArm
Curb	1/2(b+c)e(.150)	1/2(a-nL-f)+1/4(3b-c)	M_1
Slab	g[1/2(a-nL-f)+b].150	1/2[1/2(a-nL-f)+b]	M_2
FWS	1/2(a-nL-f)W_1	1/4(a-nL-f)	M_3
Rail	W_2	1/2(a-nL-f)+b-d	M_4

$\Sigma M = M_1+M_2+M_3+M_4$

2) Live Load Moment (Cantilever M)

$$E = .8X + 3.75 = .8[1/2(a-nL-f)-1] + 3.75 = .4(a-nL-f)+2.95$$

$$M = \frac{P}{E}X = \frac{P(1+I)}{.4(a-nL-f)+2.95}[1/2(a-nL-f)-1]$$

Where $P_{20} = 16^K$, $P_{15} = 12^K$, $P_{10} = 8^K$

1) + 2) = Cantilever M

STEEL GIRDER OR T-GIRDER

Interior Girder

1) Dead Load Moment

$$M_{DL} = \frac{1}{10}WS^2 = \frac{S^2}{10}[g(.150)+W_1]$$

2) Live Load Moment

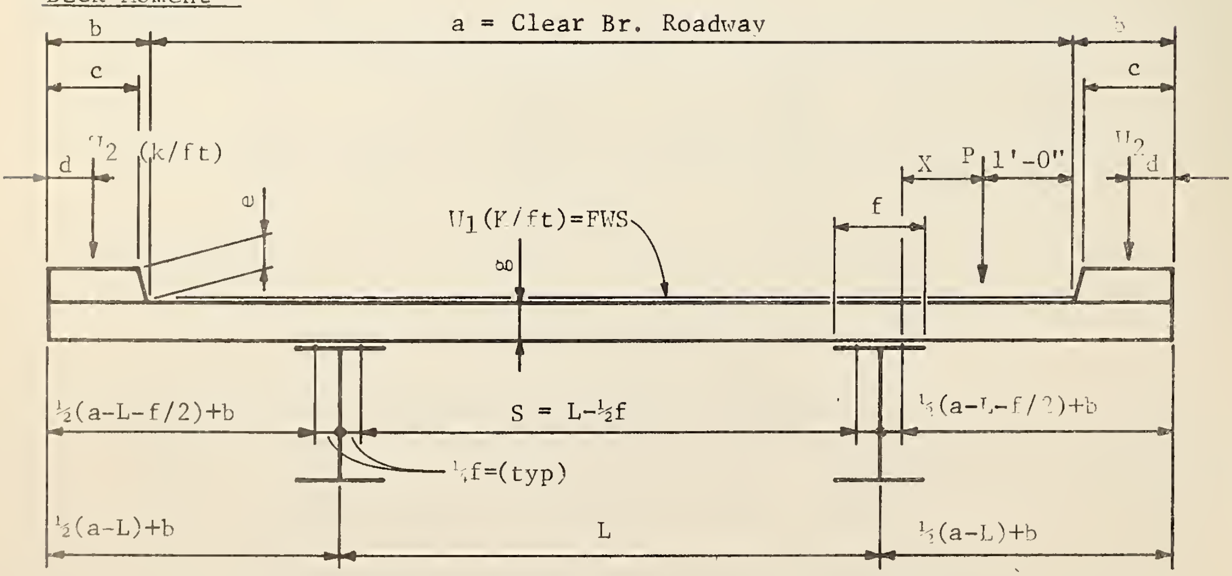
$$LLM = \frac{S+2}{32}P\ (1+I)\ (0.8)$$

Where $P_{20} = 16^K$
$P_{15} = 12^K$
$P_{10} = 8^K$

1) + 2) = + Moment
= - Moment (Compare with Cantilever M)

STEEL GIRDER (2 Girder System)

Deck Moment



a > (L+f)

Negative Moment

1) Dead Load Moment (Take M about 1/4 of top flange)

	Wt	Arm	M=WtxArm
Curb	$1/2(b+c)e(.150)$	$1/2(a-L-\frac{f}{2})+1/4(3b-c)$	M_1
Slab	$g[1/2(a-L-\frac{f}{2})+b].150$	$1/2[1/2(a-L-\frac{f}{2})+b]$	M_2
FWS	$1/2(a-L-\frac{f}{2})W_1$	$1/4(a-L-\frac{f}{2})$	M_3
Rail	W_2	$1/2(a-L-\frac{f}{2})+b-d$	M_4

$\Sigma M = M_1+M_2+M_3+M_4$

2) Live Load Moment

$E = .8X + 3.75 = .8[1/2(a-1-f/2)-1] + 3.75 = .4(a-L-f/2) + 2.95$

$$M = \frac{P}{E}X = \frac{P(1+I)}{.4(a-L-f/2)+2.95}[1/2(a-L-f/2)-1]$$

Where $P_{20} = 16^K$
$P_{15} = 12^K$
$P_{10} = 8^K$

1) + 2) = Cantilever M

Positive Moment

1) Dead Load Moment (Take M about center of span)

$R = W_2+1/2aW_1+1/2(b+c)e(.150)+1/2(a+2b)g(.150)$

	Wt	Arm	M=WtxArm
Curb	$1/2(b+c)e(.150)$	$1/2a+1/4(3b-c)$	M_1
Slab	$1/2(a+2b)g(.150)$	$(1/2a+b)1/2$	M_2
FWS	$1/2aW_1$	$1/4a$	M_3
Rail	W_2	$1/2a+b-d$	M_4

$\Sigma M = M_1+M_2+M_3+M_4$

$$+M_{\mathbb{C}} = R\frac{L}{2} - \Sigma M$$

2) Live Load Moment

$M = (P)(S+2)(1+I)/32$

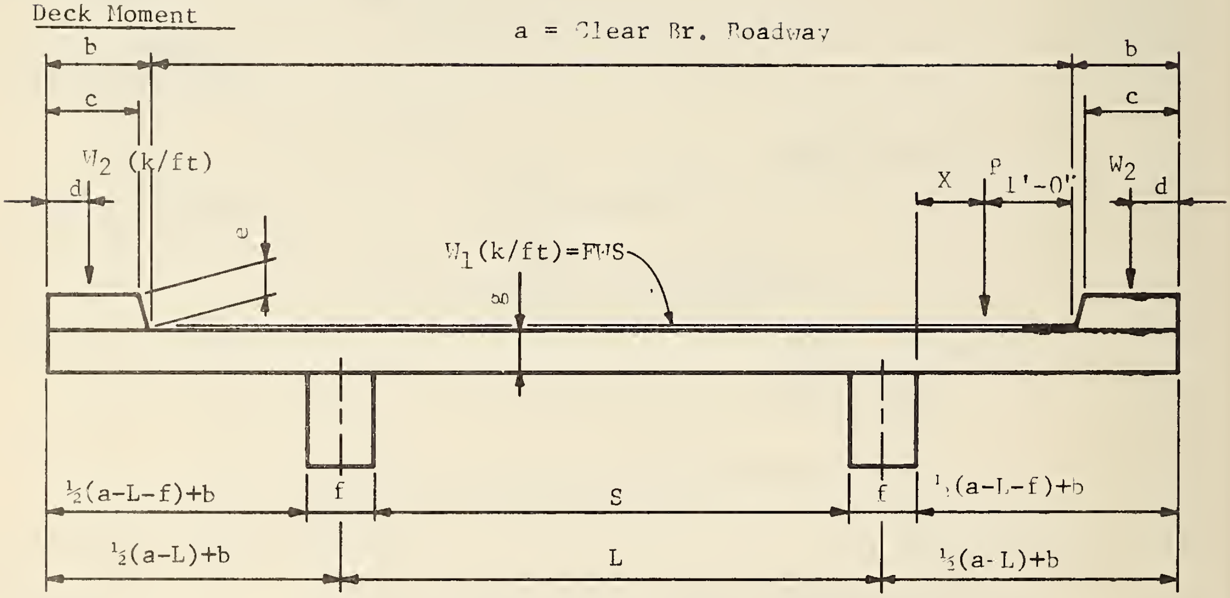
Where $P_{20} = 16^K$
$P_{15} = 12^K$
$P_{10} = 8^K$

$S = L-1/2f$

1) + 2) = + M at center of span

T-GIRDER (2 Girder System)

Deck Moment



$a > (L+f)$

Negative Moment

1) Dead Load Moment (Take M about outside face of web)

	Wt	Arm	M=WtxArm
Curb	$1/2(b+c)e(.150)$	$1/2(a-L-f)+1/4(3b-c)$	M_1
Slab	$g[1/2(a-L-f)+b].150$	$[1/2(a-L-f)+b]1/2$	M_2
FWS	$1/2(a-L-f)W_1$	$1/4(a-L-f)$	M_3
Rail	W_2	$1/2(a-L-f)+b-d$	M_4

$\Sigma M = M_1+M_2+M_3+M_4$

2) Live Load Moment

$$E = .8X + 3.75 = .8[1/2(a-L-f)-1] + 3.75 - .4(a-L-f) + 2.95$$

$$M = \frac{P}{E} X = \frac{P(1+I)}{.4(a-L-f)+2.95} [1/2(a-L-f)-1]$$

Where $P_{20} = 16^K$
$P_{15} = 12^K$
$P_{10} = 8^K$

1) + 2) = Cantilever M

Positive Moment

1) Dead Load Moment (Take M about center of span)

$$R = W_2 + 1/2aW_1 + 1/2(b+c)e(.150) + 1/2(a+2b)g(.150)$$

	Wt	Arm	M=WtxArm
Curb	1/2(b+c)e(.150)	1/2a+1/4(3b-c)	M_1
Slab	1/2(a+2b)g(.150)	(1/2a+b)1/2	M_2
FWS	$1/2aW_1$	1/4a	M_3
Rail	W_2	1/2a+b-d	M_4

$$\Sigma M = M_1+M_2+M_3+M_4$$

$$+M_{\mathbb{C}} = R\frac{L}{2} - \Sigma M$$

2) Live Load Moment

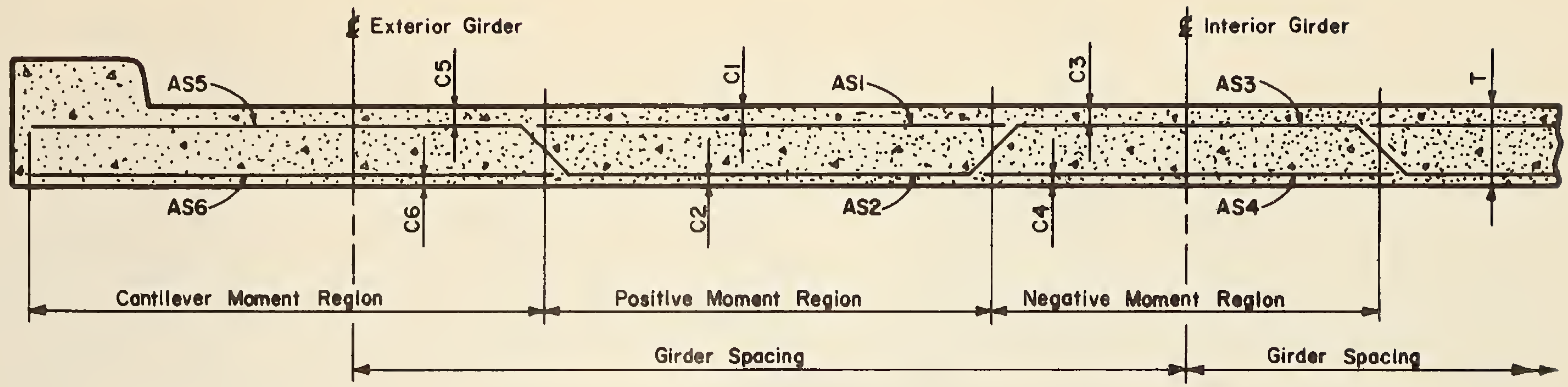
$$M = \frac{S+2}{32} P(1+I)$$

Where $P_{20} = 16^K$
$P_{15} = 12^K$
$P_{10} = 8^K$

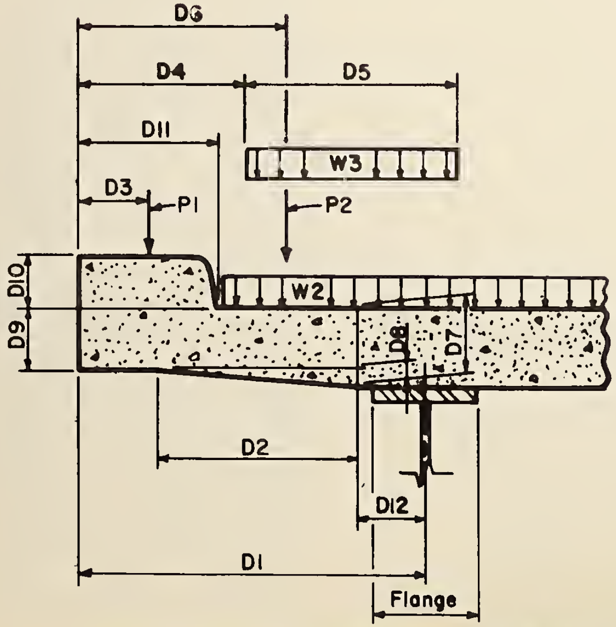
1) + 2) = + M at center of span

2.3 Description of Input. The work code entry, "DC", is made only once. Refer to Figure 13 for identification of input criteria. It should be noted that the dimensions D1 through D12 may be used for a concrete deck either on steel girders or on concrete girders. Dimensions D13 through D24 are used for unidentical cantilevers on either girder type. These dimensions may be negative if desired. The various dimensions and loads are available to allow the user some flexibility in types of cantilever configurations he may encounter. For example, a light pole mounted on the outside of the curb could be P1 and D3 would be negative. W3 could be a loading caused by several utility lines attached below the cantilever deck. The following items supplement that material shown on pages 33 thru 36.

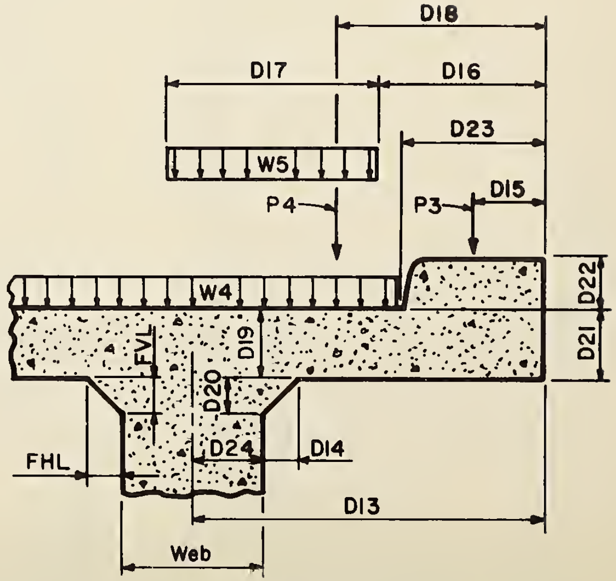
INPUT IDENTIFICATION – REINFORCED CONCRETE DECKS



REINFORCING



CANTILEVER LOADING – STEEL GIRDER



CANTILEVER LOADING – T GIRDER

Figure 13

a. Data Code 006 has entries which control the output desired and define the type of deck.

Entry #1 asks which output report is desired by the designer. A number "1" shall be entered for each report desired. It is necessary to enter a "1" for design in both cases as the rating requires the stresses from the design portion.

Entry #2 defines the type of span: 7 = simple supported; 8 = continuous over steel girders; and 9 = continuous over concrete girders.

Entry #3 defines the type of girders that support the slab: 2 = steel; 3 = concrete without fillets; and 4 = concrete with fillets.

Entry #4 defines the type of cantilevers, if any. The number 20 is entered if there are no cantilevers, 21 = identical cantilevers, and 22 = non-identical cantilevers.

Entry #5 asks if this is a timber deck. A number "1" is entered if the deck material is timber.

Entry #6 asks for the portion of impact above one that is desired; usually = .3.

b. Data Code 011 defines the reinforcing steel in a concrete deck. See Figure 13 for positioning of the steel in the deck. All areas of steel are input as square inches per foot of the deck.

Entry #1 is compressive steel in the positive moment region. (AS1)

Entry #2 is tensile steel in positive moment region. (AS2)

Entry #3 is tensile steel in negative moment region. (AS3)

Entry #4 is compressive steel in negative moment region. (AS4)

Entry #5 is distance from top of deck to centroid of compressive steel in positive moment region, in inches. (C1)

Entry #6 is distance from bottom of deck to centroid of tensile steel in positive moment region, in inches. (C2)

c. Data Code 012 is required for all runs on concrete decks and consists of the actual stresses and the allowable fractions to be used in determining the operating rating and inventory rating.

Entry #1 is the breaking strength of the concrete at the time desired, in pounds per square inch. Usually, this entry is a 28-day test.

Entry #2 is yield stress of reinforcing steel, in pounds per square inch.

Entry #3 is the fraction of yield stress of reinforcing steel to be used as allowable stress for the operating rating.

Entry #4 is the fraction of compressive stress of concrete to be used as allowable stress for the operating rating.

Entry #5 is the fraction of yield stress of reinforcing steel to be used as allowable stress for the inventory rating.

Entry #6 is the fraction of compressive stress of concrete to be used as allowable stress for the inventory rating.

d. Data Code 013 is the general data for the girder spacings, deck thickness and wheel loads. The wheel loads for the trucks are the maximum wheel loads of the corresponding trucks in the girder analysis portion. This card is always required.

Entry #1 is the girder spacing or the distance from center to center of the supports, in feet. This spacing should be altered if the reinforcing steel is skewed relative to the centerline of the girder. To obtain the proper spacing, divide the girder spacing by the cosine of the skew angle.

Entry #2 is the flange width for a steel girder or the web thickness if it is a concrete girder, in inches. If it is an I-Beam type concrete girder, this distance would equal the top flange width.

Entry #3 is the deck thickness between girders, in inches. (T)

Entry #4 is the maximum wheel load of truck loading no. 1 in the girder analysis, in kips.

Entry #5 is the maximum wheel load of truck loading no. 2, in kips.

Entry #6 is the maximum wheel load of truck loading no. 3, in kips.

e. Data Code 014. This is general data and is in all runs. See Figure 13 for location of the loads.

Entry #1 is the concentrated load on the cantilever portion, in pounds; usually the railing (pounds per foot). (P1)

Entry #2 is unit weight of reinforced concrete, in pounds per cubic foot. (W1)

Entry #3 is unit weight of wearing surface, in pounds per square foot. (W2)

Entry #4 is distance from top of slab to centroid of tensile steel in negative moment region, in inches. (C3)

Entry #5 is distance from bottom of slab to centroid of compressive steel in negative moment region, in inches. (C4)

f. Data Code 015. This card is cantilever data and is required only for decks with cantilevers. These distances are in feet for all entries. See Figure 13.

Entry #1 is the length from the centerline of the exterior girder to the outside edge of the overhanging deck. (D1)

Entry #2 is the horizontal length of the fillet or taper on the cantilever, if there is one. (D2)

Entry #3 is the distance from the outside of the deck to the concentrated load defined in Entry #1 of the 014 card. (D3)

Entry #4 is the distance from the outside of the deck to the outside edge of the miscellaneous load. (D4)

Entry #5 is the width of the miscellaneous uniform load. (D5)

Entry #6 is the distance from the outside of the deck to the concentrated load defined in the 017 card, Entry #6. (D6)

g. Data Code 016. Continuation of the 015 data.

Entry #1 is the total depth of deck at the girder for the cantilever portion, in inches. (D7)

Entry #2 is the vertical height of fillet over the girder for the cantilever, in inches. (D8)

Entry #3 is the depth of deck at outside edge of cantilever, in inches. (D9)

Entry #4 is the height of curb, in inches. (D10)

Entry #5 is the width of curb, in feet. (D11)

Entry #6 is the distance from centerline of exterior girder to where the fillet begins, in feet. (D12)

h. Data Code 017. This is miscellaneous data and is required for decks with fillets, lightweight aggregates, or for miscellaneous loads on the cantilevers. It is also used for a different impact factor on cantilever.

Entry #1 is the horizontal length of the fillet on the inside of the girder, in inches. (FHL)

Entry #2 is the vertical height of the fillet on the inside of the girder, in inches. (FVL)

Entry #3 is the modulus of elasticity ratio of steel to concrete. (n)

Entry #4 is the impact fraction to be used on cantilever if not equal to the impact fraction defined in Entry #6 of the 006 card.

Entry #5 is the weight of the miscellaneous uniform load, in pounds per square foot. (W3)

Entry #6 is the second cantilever concentrated load whose position is defined in Entry #6 of the 015 card, in pounds per foot. (P2)

i. Data Code 018. This card is filled out when there is a cantilever on the other side of the bridge that does not have the same dimensions and loadings as the one already defined. See Figure 13. All dimensions are in feet.

Entry #1 is the distance from centerline of girder to the outside edge of deck. (D13)

Entry #2 is the horizontal length of fillet. (D14)

Entry #3 is the distance from outside edge of deck to concentrated load defined in Entry #3 of the 020 card. (D15)

Entry #4 is the distance from outside edge of deck to the outside edge of the miscellaneous uniform load. (D16)

Entry #5 is the width of the miscellaneous uniform load. (D17)

Entry #6 is the distance from outside edge of deck to concentrated load defined in Entry #4 of the 020 card. (D18)

j. Data Code 019. Continuation of the 018 data.

Entry #1 is the total depth of deck over the girder for cantilever, in inches. (D19)

Entry #2 is the vertical height of the fillet for the cantilever, in inches. (D20)

Entry #3 is the depth of deck at outside edge of cantilever, in inches. (D21)

Entry #4 is the height of curb, in inches. (D22)

Entry #5 is the width of curb, in feet. (D23)

Entry #6 is the distance from centerline of girder to beginning of taper or fillet, in feet. (D24)

k. Data Code 020. Continuation of 018 data.

Entry #1 is the unit weight of wearing surface, in pounds per square foot. (W4)

Entry #2 is the weight of miscellaneous uniform load defined in Entry #5 of the 018 card, in pounds per square foot. (W5)

Entry #3 is the concentrated load on the cantilever, in pounds; usually the railing (pounds per foot). Distance is defined in Entry #3 of the 018 card. (P3)

Entry #4 is the second cantilever concentrated load whose distance is defined in Entry #6 of the 018 card. This load is to be in pounds per foot. (P4)

l. Data Code 021. Continuation of the cantilever data on the 018 card; used only if steel areas or centroids are different from those over the interior girders.

Entry #1 is tensile steel in top of deck for cantilever design, in square inches per foot. (AS5)

Entry #2 is compressive steel in bottom of deck for cantilever design, in square inches per foot. (AS6)

Entry #3 is distance from top of deck to tensile steel defined in Entry #1 of this card, in inches. (C5)

Entry #4 is distance from bottom of deck to compressive steel defined in Entry #2 of this card, in inches. (C6)

m. Data Code 022. This card is required if the decking to be designed is timber.

Entry #1 is the distance center to center of stringers, in feet.

Entry #2 is the width of the flooring member (plank), in inches.

Entry #3 is the depth of the flooring (planks), in inches.

Entry #4 is the unit weight of the timber material, in pounds per cubic foot.

Entry #5 is the weight of the wearing surface, in pounds per square foot.

Entry #6 is the width of the supporting member (stringer), in inches.

n. Data Code 023. Continuation of 022 data.

Entry #1 is the allowable bending stress in decking for the operating rating, in pounds per square inch.

Entry #2 is the allowable horizontal shear in decking for the operating rating, in pounds per square inch.

Entry #3 is the allowable bending stress in decking for the inventory rating, in pounds per square inch.

Entry #4 is the allowable horizontal shear stress in decking for the inventory rating, in pounds per square inch.

Entry #5. If the decking is continuous over more than two spans, enter "1" in this field.

Entry #6. Enter "1" in this field if it is a plank floor, a "2" if it is a laminated floor, or a "3" if it is a splined or a doweled floor.

o. Data Code 024. Loading card for the timber deck, defining the width and length of the tires. This card may be used if the user knows that the width and length of the tire print are not the same as required by the AASHO manual. See AASHO 1.3.4(A). All dimensions are in inches.

Entry #1 is the length of tire for truck no. 1 perpendicular to the decking.

Entry #2 is the width of tire for truck no. 1 parallel to the decking.

Entry #3 is the length of tire for truck no. 2 perpendicular to the decking.

Entry #4 is the width of tire for truck no. 2 parallel to decking.

Entry #5 is the length of tire for truck no. 3 perpendicular to decking.

Entry #6 is the width of tire for truck no. 3 parallel to decking.

2.4 Description of Outpuc. The output consists of the following reports:

a. Verification of Input Data
b. Design Reports
c. Rating Reports

The first report is always printed, but the last two are printed only if requested. The Design Report is printed by the mainline program. The rating data is stored on disk and is printed at the end of the girder design run.

When areas of steel in the section are omitted, the areas printed out, including compressive steel, have been calculated by the concrete design subroutine. The deck thickness assumed is that which has been defined in Entry #3 of the 013 card.

Note: The following pages including Figure 14 are prepared as summaries of the description of input. Each type of input card is portrayed with its corresponding entries and what they represent.

CODE								
ENTRY 6		Impact fraction (generally $\leq .3$)		Distance from bottom of deck to centroid of AS2 (C2) Inches		Fraction of f_c' to be used as allowable stress for Inventory Rating		Wheel load truck #3 (Maximum wheel of truck #3 in the Girder Analysis) Kips
ENTRY 5		Enter 1. for timber deck		Distance from top of deck to centroid of AS1 (C1) Inches		Fraction of f_y to be used as allowable stress for Inventory Rating		Wheel load truck #2 (Maximum wheel of truck #2 in the Girder Analysis) Kips
ENTRY 4		20=No cantilevers 21=Identical cantilevers 22=Non-identical cantilevers		Compressive steel in negative moment region (AS4) Inches^2/Ft.		Fraction of f_c' to be used as allowable stress for Operating Rating		Wheel load truck #1 (Maximum wheel of truck #1 in the Girder Analysis) Kips
ENTRY 3		2=Steel girders 3=Concrete girders without fillets 4=Concrete girders with fillets		Tensile steel in negative moment region (AS3) Inches^2/Ft.		Fraction of f_y to be used as allowable stress for Operating Rating		Slab thickness in spans (T) Inches
ENTRY 2		7=Simply supported 8=Continuous over steel girders 9=Continuous over concrete girders or timber girders		Tensile steel in positive moment region (AS2) Inches^2/Ft.		f_y-yield stress of reinforcing steel Lbs./Sq. In.		Flange width or web thickness Inches
ENTRY 1	11	Output Control Design Rating		Compressive steel in positive moment region (AS1) Inches^2/Ft.		f_c'-28 day compressive stress of concrete Lbs./Sq. In.		Girder spacing or center to center supports Feet
DATA CODE	006	CONTROL CARD	011	REINFORCED CONCRETE DECK DATA	012	MATERIALS FACTORS (Required for Concrete Decks)	013	GENERAL DATA (Always Required)
WORK CODE	DC							

ENTRY 6		Distance from outside of deck to second concentrated load, P2 Feet	Distance from centerline exterior girder to start of taper or fillet (D12) Feet	Second cantilever concentrated load (P2) Lbs./Ft.
ENTRY 5	Distance from bottom of deck to centroid of AS4 (C4) Inches	Width of miscellaneous uniform load (D5) Feet	Curb width (D11) Feet	Weight of miscellaneous uniform load (W3) Lbs./Sq. Ft.
ENTRY 4	Distance from top of deck to centroid of AS3 (C3) Inches	Distance from outside of deck to outside edge of miscellaneous uniform load (D4) Feet	Curb height (D10) Inches	Impact fraction to be used on cantilever if not equal to impact fraction for spans
ENTRY 3	Weight of wearing surface (W2) Lbs./Sq. Ft.	Distance from outside of deck to first concentrated load, P1 (D3) Feet	Depth of deck without tapers (D9) Inches	Modulus of elasticity ratio - steel to concrete (n)
ENTRY 2	Weight of concrete (W1) Lbs./Cu. Ft.	Length of taper or horizontal leg of fillet on cantilever (D2) Feet	Depth of taper or vertical leg of fillet on cantilever (D8) Inches	Vertical leg of fillets on interior spans (FVL) Inches
ENTRY 1	First cantilever concentrated load usually railing (P1) Lbs./Ft.	Cantilever length, centerline exterior girder to outside edge of deck (D1) Feet	Total depth of deck plus taper at cantilever (D7) Inches	Horizontal leg of fillets on interior spans (FHL) Inches
DATA CODE	0 1 4 GENERAL DATA (continued)	0 1 5 CANTILEVER DATA (Required only for decks with cantilevers)	0 1 6 CANTILEVER DATA (continued)	0 1 7 MISCELLANEOUS DATA (Reqd. for decks with fillets, lightweight aggregates, misc. loads on cantilever or different impact for cantilever)
WORK CODE		See Figure 13		

ENTRY 6	Distance from outside edge of deck to second concentrated load, P4 (D18) Feet	Distance from centerline exterior girder to start of taper or fillet (D24) Feet		
ENTRY 5	Width of miscellaneous uniform load (D17) Feet	Curb width (D23) Feet		
ENTRY 4	Distance from outside edge of deck to outside edge of miscellaneous uniform load (D16) Feet	Curb height (D22) Inches	Second cantilever concentrated load (P4) Lbs./Ft.	Distance from bottom of deck to AS6 Not required if C6=C4 (C6) Inches
ENTRY 3	Distance from outside edge of deck to first concentrated load, P3. (D15) Feet	Depth of deck without tapers (D21) Inches	First cantilever concentrated load usually railing (P3) Lbs./Ft.	Distance from top of deck to AS5 Not required if C5=C3 (C5) Inches
ENTRY 2	Length of taper or horizontal leg of fillet on cantilever (D14) Feet	Depth of taper or vertical leg of fillet on cantilever (D20) Inches	Weight of miscellaneous uniform load (W5) Lbs./Sq. Ft.	Compressive steel in cantilever Not required if AS6=AS4 (AS6) $Inches^2/Ft.$
ENTRY 1	Cantilever length, centerline exterior girder to outside edge of deck (D13) Feet	Total depth of deck plus taper at cantilever (D19) Inches	Weight of wearing surface (W4) Lbs./Sq. Ft.	Tensile steel in cantilever Not required if AS5=AS3 (AS5) $Inches^2/Ft.$
DATA CODE	0 1 8 CANTILEVER DATA (continued)	0 1 9 CANTILEVER DATA (continued)	0 2 0 CANTILEVER DATA (continued)	0 2 1 CANTILEVER DATA (continued)
WORK CODE	Used only when right and left cantilevers are not identical (Figure 13)			Used only if steel areas or centroids at the cantilever differ with those over the supports

	0 2 2	0 2 3	0 2 4	
ENTRY 6	Width of stringer or supporting member Inches	1=Plank floor 2=Laminated floor 3=Splined or doweled floor	Width of tire, truck #3 Inches	
ENTRY 5	Weight of wearing surface Lbs./Sq. Ft.	Enter 1. if decking is continuous over more than two spans	Length of tire, truck #3 Inches	
ENTRY 4	Weight of timber decking Lbs./Cu. Ft.	Allowable horizontal shear stress for decking (Inventory Rating) Lbs./Sq. In.	Width of tire, truck #2 Inches	
ENTRY 3	Depth of flooring member (planks) Inches	Allowable bending stress in decking (Inventory Rating) Lbs./Sq. In.	Length of tire truck #2 Inches	
ENTRY 2	Width of flooring member (planks) Inches	Allowable horizontal shear stress for decking (Operating Rating) Lbs./Sq. In.	Width of tire, truck #1 (See AASHO 1.3.4(a)) Inches	
ENTRY 1	Stringer spacing Feet	Allowable bending stress in decking (Operating Rating) Lbs./Sq. In.	Length of tire, truck #1, if other than allowed by AASHO Inches	
DATA CODE	TIMBER DECK DATA	TIMBER DECK DATA (continued)	TIMBER DECK LOADING CARD	
WORK CODE				

SUMMARY SHEET

FORM C-16
Rev. 3/11/69

//EXEC BRSYS00

WYOMING STATE HIGHWAY DEPARTMENT
CHEYENNE WYOMING
BRIDGE DIVISION

DESIGN SYSTEM

SHEET NO 1 OF 1
BY ______ DATE ______
CHECKED ______

Employee No 68	Dept Code	Per D	Job Code 75	Work Code	Str No. 80

1 COMMENT CARD

100 DECK DESIGN, REVIEW, & RATING

WORK CODE (1–2)	DATA CODE (3–5)	ENTRY 1 (6–15)	ENTRY 2 (–25)	ENTRY 3 (–35)	ENTRY 4 (–45)	ENTRY 5 (–55)	ENTRY 6 (–65)	CONT (66)
DC	006	Output Control Request (Design and Rating Reports)	Deck 7=Non-Cont 8=Cont-steel girders 9=Cont-conc girders	Girders 2=Steel 3=Conc(no fillets) 4=Conc (fillets)	Cantilevers 20= one 21=Identical 22=Non-identical	Timber deck (Enter 1.)	Impact fraction (generally .3)	
	011	Compressive steel, positive moment region (AS1)	Tensile steel, positive moment region (AS2)	Tensile steel, negative moment region (AS3)	Compressive steel, negative moment region (AS4)	Distance from top of deck to centroid of AS1 (C1)	Distance from bott of deck to centroid of AS2 (C2)	
	012	f'_c (28-day compressive stress of concrete)	f_y (yield stress of reinforcing steel)	Fraction of f_y for determining Operating Rating	Fraction of f'_c for determining Operating Rating	Fraction of f_y for determining Inventory Rating	Fraction of f'_c for determining Inventory Rating	
	013	Girder spacing or c-c supports	Flange width or web thickness	Deck thickness between girders(T)	Wheel load of truck #1	Wheel load of truck #2	Wheel load of truck #3	
	014	First cantilever point load, usually railing (P1)	Weight of concrete (W1)	Weight of wearing surface (W2)	Distance from top of slab to centroid of AS3 (C3)	Distance from bott of slab to centroid of AS4 (C4)		
	015	Length of cantilever (D1)	Length of taper or hor leg of fillet on cantilever (D2)	Distance from edge of deck to first point load, P1 (D3)	Dist from edge of deck to edge of misc unif load (D4)	Width of misc uniform load (D5)	Dist from edge of deck to second point load, P2 (D6)	
	016	Deck thickness plus taper on cantilever (D7)	Depth of taper or vert leg of fillet on cantilever (D8)	Deck thickness, taper not included (D9)	Height of curb (D10)	Width of curb (D11)	Dist from ℄ ext girder to taper or fillet (D12)	
	017	Horizontal leg of fillet on interior span (FHL)	Vertical leg of fillet on interior span (FVL)	Modulus of elasticity ratio-steel to concrete	Cantilever impact fraction (when ≠ to interior impact)	Weight of misc uniform load (W3)	Second cantilever point load (P2)	
	018	Length of cantilever, when cantilevers (D13)	Length of taper or hor leg of fillet on cantilever (D14)	Distance from edge of deck to first point load, P3(D15)	Dist from edge of deck to edge of misc unif load(D16)	Width of misc uniform load (D17)	Distance from edge of deck to second point load, P4(D18)	
	019	Deck thickness plus taper on cantilever (D19)	Depth of taper or vert leg of fillet on cantilever (D20)	Deck thickness, taper not included (D21)	Height of curb (D22)	Width of curb (D23)	Dist from ℄ ext girder to taper or fillet (D24)	
	020	Weight of wearing surface (W4)	Weight of misc uniform load (W5)	First cantilever point load, usually railing (P3)	Second cantilever point load (P4)			
	021	Tensile steel, cantilever, not reqd if AS5=AS3 (AS5)	Comp steel, cantilever, not reqd if AS6=AS4 (AS6)	Distance from top of deck to centroid of AS5 (C5)	Distance from bott of deck to centroid of AS6 (C6)			
	022	Timber Decks stringer spacing	Width of flooring member (plank)	Thickness of flooring member (plank)	Weight of timber decking	Weight of wearing surface	Width of stringer or supporting member	
	023	Allowable bending stress--decking (Operating Rating)	Allowable hor shear stress--decking (Operating Rating)	Allowable bending stress--decking (Inventory Rating)	Allowable hor shear stress--decking (Inventory Rating)	Decking continuous over more than two stringers(Enter 1.)	Deck 1=Plank 2=Laminated 3=Splined/doweled	
	024	Length of tire, truck #1 (if not as in AASHO specs)	Width of tire, truck #1 (see AASHO 1.3.4(A)	Length of tire, truck #2	Width of tire, truck #2	Length of tire, truck #3	Width of tire, truck #3	

TRAILER CARD

999 (1–3)

NOTE: A trailer card must follow the last structure card containing data

Figure 14

3. GIRDER DESIGN, REVIEW AND RATING

3.1 Structural Analysis

3.1.1 General Information. The series of programs in this Section, called "Structural Analysis", is a group of programs designed and inter-connected in such a way that the designer is given a great deal of freedom in design and analysis.

Input is minimized through selection of the basic structure. First, the designer must think of his structure as a series of lines. Then, he must impose upon this linear layout the elevations, or thickness of each member, which we will call spans. After being satisfied with the aesthetics of the planar layout, he must give each span its depth; in other words, define the cross section.

Output is in various forms and may be requested as needed. The beginning user may wish to have all reports such as "Beam Properties", "Beam Characteristics" and "Influence Lines". After becoming familiar with the system it is possible that these reports may not be needed.

There are four main programs in this series. They are:

a. Beam Properties. The "Beam Properties" programs calculates for each twentieth point of the span:

Beam depth
Cross-sectional area
Moment of inertia
Distance to centroid of area
Thickness of web
Flange thickness of top flange
Flange thickness of bottom flange
Flange width of top flange
Flange width of bottom flange

The span ratio and method of depth variation are also given for each span.

b. Beam Characteristics and Fixed End Moments. The "Beam Characteristics and Fixed End Moments" program determines the relative stiffness and carryover factor for each end of each span. It then determines the fixed end moments for a unit load at each tenth point of each span.

c. Indeterminate Coefficients. The "Indeterminate Coefficients" program sets up the equations for indeterminacy and inverts the matrix of constant coefficients. The inverted matrix is used by successive programs to determine influence line coefficients. The inversion, if obtained, can be a handy tool for investigating various loading conditions on the structure, such as horizontal live load, settlement of supports, shrinkage, etc.

d. Influence Lines. The "Influence Line" series applies loads to each tenth point of each span and finds the shears at each

end of each span and calculates the moments at each tenth point (including ends of spans) of each span. The areas are then calculated for each influence line.

All coefficients are relative to the first span length, making use of the lines easy.

The "basic structure" (Figure 41), previously mentioned, is called the cell type layout. Most bridge structures can be designed using the members within this layout. One must only define those spans that are in his particular structure.

Many types of frames may be analyzed, such as piers, abutments, box girder sections and the like.

The "continuous type layout" is to be used when there are more than six continuous spans. The nineteen spans maximum allows an analytical approach to the design of such things as floor beams for arches, etc.

The "slant leg layout" is a routine for the design of a three (or five) span slant leg bridge. Sidesway and settlement of the joints C, E, G, and I are allowed in this structure. Various other structures may be designed by omitting different spans.

Ranges and restrictions are:

a. Maximum number of cross section ranges for any one span is eighteen.
b. Maximum number of cross sections for one structure is ten.
c. Maximum number of web depths for a span is five.
d. Ranges for web depth are always measured from left to right from the center line of bearing of the span.
e. The moment of inertia of a span may be used to describe a span.
f. Span number one of the designer's structure must be the same as span number one of the example sketches. Refer to Figures 41 thru 43, page 72.
g. Maximum number of continuous spans is nineteen.
h. Maximum number of cells is six.
i. Maximum number of upper spans in a slant leg structure is five.
j. The joint at the left end of any span entered by a 401 or 402 card will be fixed. The maximum number of joints that can be fixed is seven.
k. The left ends of the vertical (or canted) spans are considered to be at the top.
l. Only one span may frame into a given fixed joint.
m. Only cell one through six and cell nine type structures may have fixed joints. That is, structures may be made by excluding members of any cell to leave the desired structure.

3.1.2 Mathematical Equations and Derivations. DC101, Beam Characteristics and Fixed End Moments.

General. This program will find the stiffness and carryover factors for both ends of any shaped beam. The required information is moment of inertias, or inertia ratios, at both sides of each twentieth point of the span. This was chosen so an abrupt change in a section could be handled.

Method of Analysis. The method of analysis is column analogy[1]. The elastic

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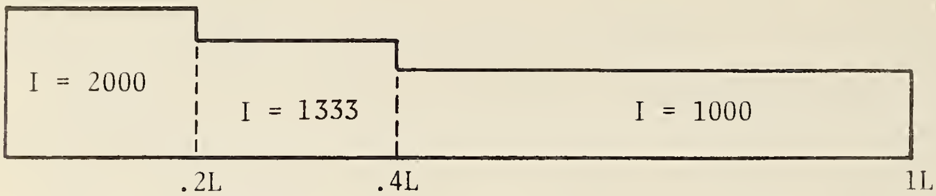
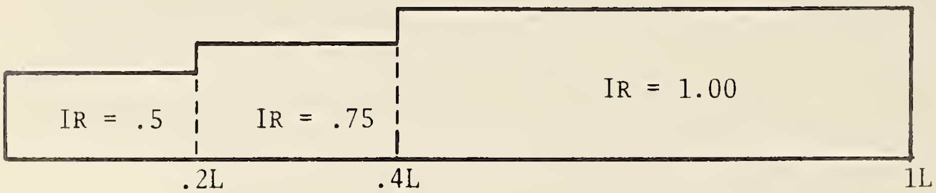
[1]Indeterminate Structural Analysis, J. Sterling Kinney; Addison-Wesley Publishing Co., Inc., 1957; Chapter 10, Section 10-2, P. 445

loads for fixed end moments are derived for point loads only. The point loads are placed at each successive tenth point of the span.

The analogous column is built up by dividing the minimum moment of inertia by the average moment of inertia for each segment. See Figures 15 and 16.



POSSIBLE MOMENT OF INERTIA PATTERN
Figure 15



RESULTING ANALOGOUS COLUMN
Figure 16

The areas and moments of the areas are calculated for all segments and summed up. The distance from the left end to the centroid of the column is next calculated by dividing the summation of moments by the summation of areas.

Next, the moment of inertia of the analogous column is calculated about its own centroid.

By definition, the stiffness of a member is that moment necessary to rotate the end of the member one radian. So a load of one radian is applied at one end at a time and the resultant flexural strains are calculated from the flexural strain formula:

$F = P/A \pm Pec/I$ which, with a unit load, breaks down to $1/\text{Area} \pm ec/I$,

Where
- e = eccentricity of load
- c = distance to calculated strain
- I - moment of inertia of analogous column

$FL = 1/\text{Area} + X_0^2/I$, $F_2 = 1/\text{Area} - X_0(L-X_0)/I$, $FR = 1/\text{Area} + (L-X_0)^2/I$,

Where X_0 = distance to centroid of column
- FL = relative stiffness at the left end
- FR = relative stiffness at the right end

Again, by definition, the carryover is that portion of the moment that will go to the opposite end of a member when the end has rotated one

radian. Therefore, F2 is the amount and F2/FL is the carryover factor for the left end and F2/FR is the carryover factor for the right end.

To demonstrate, Table I will show the calculations for the stiffness of the member found in Figure 16. The table will use only three segments, although the program uses twenty.

Segment	Ordinate	Length	Area	Moment Arm	Moment	$I_c = b\frac{d^3}{12}$	$I_t = A\,d^2$
1	.5	.2	.1	.1	.01	$(.5)\ .2^3/12 = .00033$	$(.1)\ .46^2 = .02116$
2	.75	.2	.15	.3	.045	$(.75)\ .2^3/12 = .0005$	$(.15)\ .26^2 = .01014$
3	1.00	.6	.6	.7	.42	$(1)\ .6^3/12 = .018$	$(.6)\ .14^2 = .01176$
			.85		.475	.01883	.04306

$X_0 = \frac{.475}{.85} = .5588$ $\qquad I = .01883 + .04306 = .06189$

$FL = \frac{1}{.85} + \frac{.5588^2}{.06189} = 6.2218$

$FR = \frac{1}{.85} + \frac{(1 - .5588)^2}{.06189} = 4.3217$

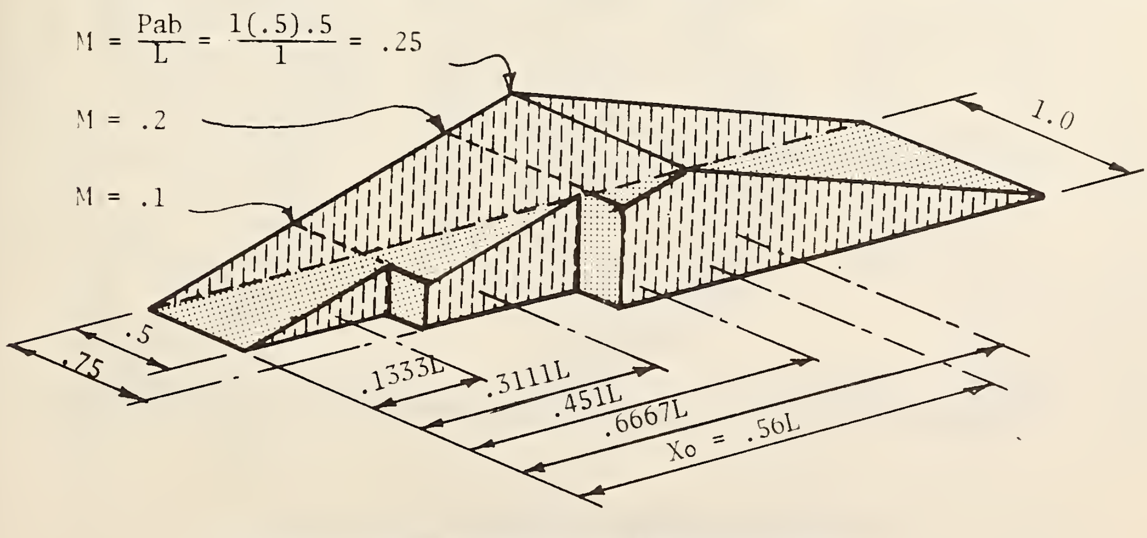
$F2 = \frac{1}{.85} - \frac{(1 - .5588)\ .5588}{.06189} = -2.8071$

$CL = \frac{-2.8071}{6.2218} = -.45117$ $\qquad CR = \frac{-2.8071}{4.3217} = -.6495$

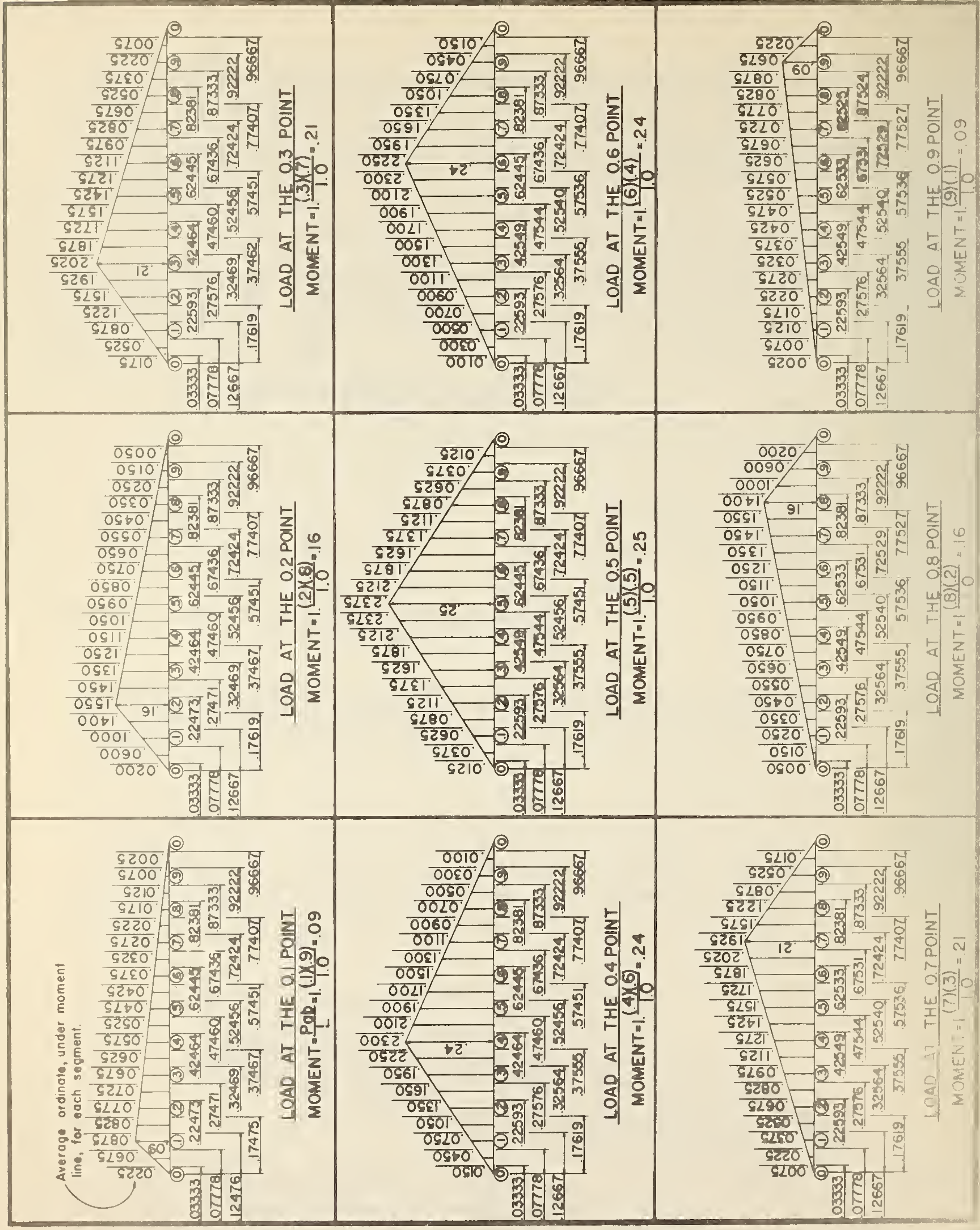
TABLE I

The calculations for fixed end moments are a continuation of the stiffness and carryover calculations. The elastic load is the simple beam moment diagram which is imposed over the analogous column. The volume of the moment diagram with a width equal to the ordinates of the column is calculated as illustrated in Figure 17 and Table II.

The moment of the volume about the centroid is then calculated and the flexure formula again applied to find the strains at each end. Table II illustrates the calculations for the problem in Figure 17, with the unit load at the center of the span. The fixed end moments (FEM) are represented by the flexure caused



ANALOGOUS COLUMN LOADED WITH MOMENT DIAGRAM
(Unit load at 0.5 L)
FIGURE 17



ELASTIC LOAD AREAS AND DISTANCES TO CENTROIDS OF AREAS
Figure 18

by the loading, just as in the stiffness case. Fixed end moments for any other loading condition may be calculated in exactly the same manner.

SEG.	AVG. ORD	LENGTH	WIDTH	VOLUME	ARM	MOMENT
1	$\frac{0+.1}{2}$	.2	.5	.005	-.56+.133=-.427	-.002135
2	$\frac{.1+.2}{2}$	.2	.75	.0225	-.56+.311=-.249	-.00560
3	$\frac{.2+.25}{2}$	.1	1.	.0225	-.56+.451=-.109	-.00245
4	$\frac{.25+0}{2}$	.5	1.	.0625	-.56+.667=.107	.00668
				.1125		-.00351

$$FEM_L = \frac{.1125}{.85} + \frac{-.00351(-.56)}{.06189} = .132 + .0317 = .1637$$

$$FEM_R = \frac{.1125}{.85} + \frac{-.00351(.44)}{.06189} = .132 - .0249 = .1071$$

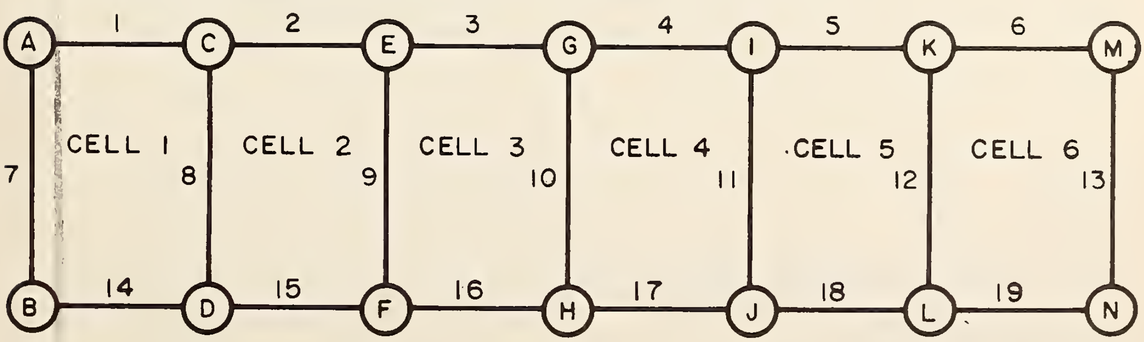
TABLE II

It may be noted that the average ordinates and distances to the centroids of the segments are independent of the width of the analogous column for any given moment diagram. A table of values has been prepared for each ordinate and distance, as illustrated in Figure 18, and the resulting values have been stored in the program.

DC401, Standard Analysis

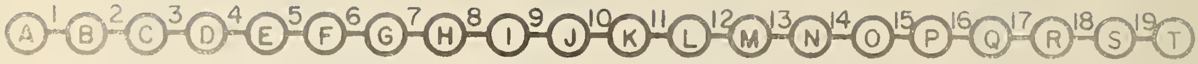
General. This program includes the analysis for all six of the cell type structures (single cell, double cell, etc. thru six cells); the six span integral leg structure, called cell seven; six span continuous (cell eight); 19 span continuous, denoted as cell number nine.

The cell structure with its nomenclature is used for the first eight cells (cell number one thru eight, plus cells ten and eleven) and is shown in Figure 19. The 19 span continuous structure (cell nine) has a different nomenclature and may be found in Figure 20.



NOMENCLATURE OF CELL STRUCTURE

Figure 19



NOMENCLATURE OF 19 SPAN CONTINUOUS STRUCTURE
Figure 20

Method of Analysis. The slope-deflection method[2] is the method used in the analysis of the cell structure. Equations were written for each member (span) and set up in a matrix equation form for inversion.

The general conditions of the structure are:

a. Sidesway was not allowed ; displacement angles at joints B, D, F, H, J, L and N of spans 7 thru 13 respectively equal zero.

b. Settlement at supports was not allowed, all other displacement angles equal zero.

DEFINITION OF TERMS

MAC = Final moment (after distribution at joint A in member AC [span 1])
FAB = Fixed end moment at joint A in member AB (span 7)
θA = rotation of joint A due to moment distribution
KAC = Relative stiffness in member AC at end A
CCA = Carryover factor in member AC at end C
SAC = KAC times CAC = KCA times CCA
ρ7 = Displacement angle of span 7

SINGLE CELL ANALYSIS

Slope-deflection equations are:

1.1 MAB = FAB - KAB x θA - CBA x KBA x θB + (KAB + CBA x KBA) x ρ7
1.2 MAC = FAC - KAC x θA - CCA x KCA x θC + (KAC + CCA x KCA) x ρ1
1.3 MBA = FBA - KBA x θB - CAB x KAB x θA + (KBA + CAB x KAB) x ρ7
1.4 MBD = FBD - KBD x θB - CDB x KDB x θD + (KBD + CDB x KDB) x ρ14
1.5 MCA = FCA - KCA x θC - CAC x KAC x θA + (KCA + CAC x KAC) x ρ1
1.6 MCD = FCD - KCD x θC - CDC x KDC x θD + (KCD + CDC x KDC) x ρ8
1.7 MDB = FDB - KDB x θD - CBD x KBD x θB + (KDB + CBD x KBD) x ρ14
1.8 MDC = FDC - KDC x θD - CCD x KCD x θC + (KDC + CCD x KCD) x ρ8

Statical condition equations are:

2.1 MAB = - MAC
2.2 MBD = - MBA
2.3 MCD = - MCA
2.4 MDB = - MDC
2.5 ρ1, ρ7, ρ8 and ρ14 = zero

Set identities are:

[2] Ibid, page 477

3.1 SAC = KAC x CAC = KCA x CCA
3.2 SAB = KAB x CAB = KBA x CBA
3.3 SBD = KBD x CBD = KDB x CDB
3.4 SCD = KCD x CCD = KDC x CDC

Substituting equations 2 and 3 into equations 1 and arranging in matrix form, we get the matrices displayed in Figure 21.

$$
\begin{bmatrix}
1. & & & & KAC & & SAC & \\
 & 1. & & & SAB & KBA & & \\
 & & 1. & & SAC & & KCA & \\
 & & & 1. & & & SCD & KDC \\
-1. & & & & KAB & SAB & & \\
 & -1. & & & & KBD & & SBD \\
 & & -1. & & & & KCD & SCD \\
 & & & -1. & & & SBD & KDB
\end{bmatrix}
\times
\begin{bmatrix}
MAC \\ MBA \\ MCA \\ MDC \\ \theta A \\ \theta B \\ \theta C \\ \theta D
\end{bmatrix}
=
\begin{bmatrix}
FAC \\ FBA \\ FCA \\ FDC \\ FAB \\ FBD \\ FCD \\ FDB
\end{bmatrix}
$$

ONE CELL MATRICES
Figure 21

DOUBLE CELL ANALYSIS

Slope-deflection equations. The equations of single cell are valid and the additional equations are:

1.9 MCE = FCE - KCE x θC - CEC x KEC x θE
1.10 MEC = FEC - KEC x θE - CCE x KCE x θC
1.11 MDF = FDF - KDF x θD - CFD x KFD x θF
1.12 MFD = FFD - KFD x θF - CDF x KDF x θD
1.13 MEF = FEF - KEF x θE - CFE x KFE x θF
1.14 MFE = FFE - KFE x θF - CEF x KEF x θE

Statical condition equations are:

2.1 MAB = - MAC
2.2 MBD = - MBA
2.3 MFD = - MFE
2.4 MEF = - MEC
2.5 MCD = - (MCA + MCE)
2.6 MDF = - (MDB + MDC)

Set identities (additional) are:

SCE = KCE x CCE = KEC x CEC
SDF = KDF x CDF = KFD x CFD
SEF = KEF x CEF = KFE x CFE

Again, by substitution and arranging in matrix form, we get the matrices displayed in Figure 22.

$$
\begin{bmatrix}
1 & & & & & & & & KAC & & SAC & & & \\
 & 1 & & & & & & & SAB & KBA & & & & \\
 & & 1 & & & & & & SAC & & KCA & & & \\
 & & & 1 & & & & & & & KCE & & SCE & \\
 & & & & 1 & & & & & SBD & & KDB & & \\
 & & & & & 1 & & & & & SCD & KDC & & \\
 & & & & & & 1 & & & & SCE & & KEC & \\
 & & & & & & & 1 & & & & & SEF & KFE \\
-1 & & & & & & & & KAB & SAB & & & & \\
 & -1 & & & & & & & & KBD & & SBD & & \\
 & & -1 & -1 & & & & & & & KCD & SCD & & \\
 & & & & -1 & -1 & & & & & & KDF & & SDF \\
 & & & & & & -1 & & & & & & KEF & SEF \\
 & & & & & & & -1 & & & & SDF & & KFD
\end{bmatrix}
\times
\begin{bmatrix} MAC \\ MBA \\ MCA \\ MCE \\ MDB \\ MDC \\ MEC \\ MFE \\ \theta A \\ \theta B \\ \theta C \\ \theta D \\ \theta E \\ \theta F \end{bmatrix}
=
\begin{bmatrix} FAC \\ FBA \\ FCA \\ FCE \\ FDB \\ FDC \\ FEC \\ FFE \\ FAB \\ FBD \\ FCD \\ FDF \\ FEF \\ FFD \end{bmatrix}
$$

TWO CELL MATRICES
Figure 22

TRIPLE CELL ANALYSIS

Slope-deflection equations. The previous equations are valid and the additional equations are:

1.15 MEG = FEG - KEG x θE - CGE x KGE x θG
1.16 MGE = FGE - KGE x θG - CEG x KEG x θE
1.17 MGH = FGH = KGH x θG - CHG x KHG x θH
1.18 MHG = FHG - KHG x θH - CGH x KGH x θG
1.19 MFH = FFH - KFH x θF - CHF x KHF x θH
1.20 MHF = FHF - KHF x θH - CFH x KFH x θF

Statical condition equations and identities are:

2.1 MAB = - MAC
2.2 MBD = - MBA
2.3 MHF = - MHG
2.4 MGH = - MGE
2.5 MCD = - (MCA + MCE)
2.6 MDF = - (MDC + MDB)
2.7 MEF = - (MEC + MEG)
2.8 MFH = - (MFE + MFD)

3.1 SAB = KAB x CAB = KBA x CBA
3.2 SCD = KCD x CCD = KDC x CDC
3.3 SCE = KCE x CCE = KEC x CEC
3.4 SDF = KDF x CDF = KFD x CFD
3.5 SEG = KEG x CEG = KGE x CGE
3.6 SFH = KFH x CFH = KHF x CHF
3.7 SAC = KAC x CAC = KCA x CCA
3.8 SBD = KBD x CBD = KDB x CDB
3.9 SEF = KEF x CEF = KFE x CFE
3.10 SGH - KGH x CGH = KHG x CHG

By substituting equations 2 and 3 into 1 and arranging into matrix form, we get the matrices displayed in Figure 23.

FOUR CELL ANALYSIS

Slope-deflection equations. Previous equations are valid. The new equations required are:

1.21 MGI = FGI - KGI x θG - KIG x CIG x θI
1.22 MIG = FIG - KIG x θI - KGI x CGI x θG
1.23 MIJ = FIJ - KIJ x θI - KJI x CJI x θJ
1.24 MJI = FJI - KJI x θJ - KIJ x CIJ x θI
1.25 MJH = FJH - KJH x θJ - KHJ x CHJ x θH
1.26 MHJ = FHJ - KHJ x θH - KJH x CJH x θJ

Statical condition equations and identities are:

2.1 MAB = - MAC
2.2 MBD = - MBA
2.3 MJH = - MJI
2.4 MIJ = - MIG
2.5 MCD = - (MCA + MCE)
2.6 MDF = - (MDC + MDB)
2.7 MEF = - (MEC + MEG)
2.8 MFH = - (MFE + MFD)
2.9 MGH = - (MGE X MGI)
2.10 MHJ = - (MHG + MHF)

3.1 SAB = KAB x CAB = KBA x CBA
3.2 SCD = KCD x CCD = KDC x CDC
3.3 SCE = KCE x CCE = KEC x CEC
3.4 SDF = KDF x CDF = KFD x CFD
3.5 SEG = KEG x CEG = KGE x CGE
3.6 SFH = KFH x CFH = KHF x CHF
3.7 SGI = KGI x CGI = KIG x CIG
3.8 SHJ = KHJ x CHJ = KJH x CJH
3.9 SAC = KAC x CAC = KCA x CCA
3.10 SBD = KBD x CBD = KDB x CDB
3.11 SEF = KEF x CEF = KFE x CFE
3.12 SGH = KGH x CGH = KHG x CHG
3.13 SIJ = KIJ x CIJ = KJI x CJI

By substituting equations 2 and 3 into 1 and arranging into matrix form, we get the matrices displayed in Figure 25, page 53.

1.												KAC		SAC							MAC		FAC
	1.											SAB	KBA								MBA		FBA
		1.										SAC		KCA							MCA		FCA
			1.											KCE		SCE					MCE		FCE
				1.									SBD		KDB						MDB		FDB
					1.									SCD	KDC						MDC		FDC
						1.								SCE		KEC					MEC		FEC
							1.									KEG		SEG			MEG		FEG
								1.							SDF		KFD				MFD		FFD
									1.							SEF	KFE			X	MFE	=	FFE
										1.						SEG		KGE			MGE		FGE
											1.							SGH	KHG		MHG		FHG
-1.												KAB	SAB								θA		FAB
	-1.												KBD		SBD						θB		FBD
		-1.	-1.											KCD	SCD						θC		FCD
				-1.	-1.										KDF		SDF				θD		FDF
						-1.	-1.									KEF	SEF				θE		FEF
								-1.	-1.								KFH		SFH		θF		FFH
										-1.								KGH	SGH		θG		FGH
											-1.						SFH		KHF		θH		FHF

THREE CELL MATRICES
Figure 23

FIVE CELL ANALYSIS

Slope-deflection equations. Previous equations are valid. The new equations required are:

1.27 MIK = FIK - KIK x θI - KKI x CKI x θK
1.28 MKI = FKI - KKI x θK - KIK x CIK x θI
1.29 MKL = FKL - KKL x θK - KLK x CLK x θL
1.30 MLK = FLK - KLK x θL - KKL x CKL x θK
1.31 MLJ = FLJ - KLJ x θL - KJL x CJL x θJ
1.32 MJL = FJL - KJL x θJ - KLJ x CLJ x θL

Statical condition equations and identities are:

2.1 MAB = - MAC
2.2 MBD = - MBA
2.3 MLJ = - MLK
2.4 MKL = - MKI
2.5 MCD = - (MCA + MCE)
2.6 MDF = - (MDC + MDB)
2.7 MEF = - (MEC + MEG)
2.8 MFH = - (MFE + MFD)
2.9 MGH = - (MGE + MGI)
2.10 MHJ = - (MHG + MHF)
2.11 MIJ = - (MIG + MIK)
2.12 MJL = - (MJI + MJH)

3.1 SAB = KAB x CAB = KBA x CBA
3.2 SCD = KCD x CCD = KDC x CDC
3.3 SCE = KCE x CCE = KEC x CEC
3.4 SDF = KDF x CDF = KFD x CFD
3.5 SEG = KEG x CEG = KGE x CGE
3.6 SFH = KFH x CFH = KHF x CHF
3.7 SKL = KKL x CKL = KLK x CLK
3.8 SGI = KGI x CGI = KIG x CIG
3.9 SHJ = KHJ x CHJ = KJH x CJH
3.10 SIK = KIK x CIK = KKI x CKI
3.11 SJL = KJL x CJL = KLJ x CLJ
3.12 SAC = KAC x CAC = KCA x CCA
3.13 SBD = KBD x CBD = KDB x CDB
3.14 SEF = KEF x CEF = KFE x CFE
3.15 SGH - KGH x CGH = KHG x CHG
3.16 SIJ = KIJ x CIJ = KJI x CJI

By substituting equations 2 and 3 into 1 and arranging into matrix form, we get the matrices displayed in Figure 27, page 54.

SIX CELL ANALYSIS

Slope-deflection equations. The previous equations are valid and the new equations are:

1.33 MKM = FKM - KKM x θK - KMK x CMK x θM
1.34 MMK = FMK - KMK x θM - KKM x CKM x θK
1.35 MMN = FMN - KMN x θM - KNM x CNM x θN
1.36 MNM = FNM - KNM x θN - KMN x CMN x θM
1.37 MNL = FNL - KNL x θN - KLN x CLN x θL
1.38 MLN = FLN - KLN x θL - KNL x CNL x θN

Statical condition equations and identities are:

2.1 MAB = - MAC
2.2 MBD = - MBA
2.3 MMN = - MMK
2.4 MNL = - MNM
2.5 MCD = - (MCA + MCE)
2.6 MDF = - (MDC + MDB)
2.7 MEF = - (MEC + MEG)

2.8 MFH = - (MFE + MFD)
2.9 MGH = - (MGE + MGI)
2.10 MHJ = - (MHG + MHF)
2.11 MJL = - (MJI + MJH)
2.12 MIJ = - (MIG + MIK)
2.13 MKL = - (MKI + MKM)
2.14 MLN = - (MLK + MLJ)

3.1 SAB = KAB x CAB = KBA x CBA
3.2 SCD = KCD x CCD = KDC x CDC
3.3 SCE = KCE x CCE = KEC x CEC
3.4 SDF = KDF x CDF = KFD x CFD
3.5 SEG = KEG x CEG = KGE x CGE
3.6 SFH = KFH x CFH = KHF x CHF
3.7 SMN = KMN x CMN = KNM x CNM
3.8 SGI = KGI x CGI = KIG x CIG
3.9 SHJ = KHJ x CHJ = KJH x CJH
3.10 SIK = KIK x CIK = KKI x CKI
3.11 SJL = KJL x CJL = KLJ x CLJ
3.12 SKM = KKM x CKM = KMK x CMK
3.13 SLN = KLN x CLN = KNL x CNL
3.14 SAC = KAC x CAC = KCA x CCA
3.15 SBD = KBD x CBD = KDB x CDB
3.16 SEF = KEF x CEF = KFE x CFE
3.17 SGH = KGH x CGH = KHG x CHG
3.18 SIJ = KIJ x CIJ = KJI x CJI
3.19 SKL = KKL x CKL = KLK x CLK

By substituting equations 2 and 3 into 1 and arranging into matrix form, we get the matrices displayed in Figure 28, page 55.

SEVEN CELL ANALYSIS (Six span integral leg structure)

Slope-deflection equations are:

1.2 MAC = FAC - KAC x θA - KCA x CCA x θC
1.5 MCA = FCA - KCA x θC - KAC x CAC x θA
1.6 MCD = FCD - KCD x θC - KDC x CDC x θD
1.8 MDC = FDC - KDC x θD - KCD x CCD x θC
1.9 MCE = FCE - KCE x θC - KEC x CEC x θE
1.10 MEC = FEC - KEC x θE - KCE x CCE x θC
1.13 MEF = FEF - KEF x θE - KFE x CFE x θF
1.14 MFE = FFE - KFE x θF - KEF x CEF x θE
1.15 MEG = FEG - KEG x θE - KGE x CGE x θG
1.16 MGE = FGE - KGE x θG - KEG x CEG x θE
1.17 MGH = FGH - KGH x θG - KHG x CHG x θH
1.18 MHG = FHG - KHG x θH - KGH x CGH x θG
1.21 MGI = FGI - KGI x θG - KIG x CIG x θI
1.22 MIG = FIG - KIG x θI - KGI x CGI x θG
1.23 MIJ = FIJ - KIJ x θI - KJI x CJI x θJ
1.24 MJI = FJI - KJI x θJ - KIJ x CIJ x θI
1.27 MIK = FIK - KIK x θI - KKI x CKI x θK
1.28 MKI = FKI - KKI x θK - KIK x CIK x θI
1.29 MKL = FKL - KKL x θK - KLK x CLK x θL
1.30 MLK = FLK - KLK x θL - KKL x CKL x θK
1.33 MKM = FKM - KKM x θK - KMK x CMK x θM
1.34 MMK = FMK - KMK x θM - KKM x CKM x θK

Statical condition equations and identities are:

2.1 MAC = Zero
2.2 MDC = Zero
2.3 MFE = Zero
2.4 MHG = Zero
2.5 MJI = Zero
2.6 MLK = Zero
2.7 MMK = Zero
2.8 MCD = - (MCA + MCE)
2.9 MEF = - (MEC + MEG)
2.10 MGH = - (MGE + MGI)
2.11 MIJ = - (MIG + MIK)
2.12 MKL = - (MKI + MKM)

3.1 SAC = KAC x CAC = KCA x CCA
3.2 SCD = KCD x CCD = KDC x CDC
3.3 SCE = KCE x CCE = KEC x CEC
3.4 SEF = KEF x CEF = KFE x CFE
3.5 SEG = KEG x CEG = KGE x CGE
3.6 SGH = KGH x CGH = KHG x CHG
3.7 SGI = KGI x CGI = KIG x CIG
3.8 SIJ = KIJ x CIJ = KJI x CJI
3.9 SIK = KIK x CIK = KKI x CKI
3.10 SKL = KKL x CKL = KLK x CLK
3.11 SKM = KKM x CKM = KMK x CMK

By substituting equations 2 and 3 into 1 and arranging into matrix form, we get the matrices displayed in Figure 26, page 53.

EIGHT CELL ANALYSIS (Six span continuous structure)

Slope-deflection equations are:

1.2 $MAC = FAC - KAC \times \theta A - KCA \times CCA \times \theta C$
1.5 $MCA = FCA - KCA \times \theta C - KAC \times CAC \times \theta A$
1.9 $MCE = FCE - KCE \times \theta C - KEC \times CEC \times \theta E$
1.10 $MEC = FEC - KEC \times \theta E - KCE \times CCE \times \theta C$
1.15 $MEG = FEB - KEG \times \theta E - KGE \times CGE \times \theta G$
1.16 $MGE = FGE - KGE \times \theta G - KEG \times CEG \times \theta E$
1.21 $MGI = FGI - KGI \times \theta G - KIG \times CIG \times \theta I$
1.22 $MIG = FIG - KIG \times \theta I - KGI \times CGI \times \theta G$
1.27 $MIK = FIK - KIK \times \theta I - KKI \times CKI \times \theta K$
1.28 $MKI = FKI - KKI \times \theta K - KIK \times CIK \times \theta I$
1.33 $MKM = FKM - KKM \times \theta K - KMK \times CMK \times \theta M$
1.34 $MMK = FMK - KMK \times \theta M - KKM \times CKM \times \theta K$

Statical condition equations and identities are:

2.1 $MAC = \text{Zero}$
2.2 $MMK = \text{Zero}$
2.3 $MCA = - MCE$
2.4 $MEC = - MEG$
2.5 $MGE = - MGI$
2.6 $MIG = - MIK$
2.7 $MKI = - MKM$

3.1 $SAC = KAC \times CAC = KCA \times CCA$
3.2 $SCE = KCE \times CCE = KEC \times CEC$
3.3 $SEG = KEG \times CEG = KGE \times CGE$
3.4 $SGI = KGI \times CGI = KIG \times CIG$
3.5 $SIK = KIK \times CIK = KKI \times CKI$
3.6 $SKM = KKM \times CKM = KMK \times CMK$

By substituting equations 2 and 3 into 1 and arranging into matrix form, we get the matrices displayed in Figure 24.

$$
\begin{bmatrix}
1 & & & & & S_{AC} & K_{CA} & & & & & \\
 & 1 & & & & & S_{CE} & K_{EC} & & & & \\
 & & 1 & & & & & S_{EG} & K_{GE} & & & \\
 & & & 1 & & & & & S_{GI} & K_{IG} & & \\
 & & & & 1 & & & & & S_{IK} & K_{KI} & \\
 & & & & & K_{AC} & S_{AC} & & & & & \\
-1 & & & & & & K_{CE} & S_{CE} & & & & \\
 & -1 & & & & & & K_{EG} & S_{EG} & & & \\
 & & -1 & & & & & & K_{GI} & S_{GI} & & \\
 & & & -1 & & & & & & K_{IK} & S_{IK} & \\
 & & & & -1 & & & & & & K_{KM} & S_{KM} \\
 & & & & & & & & & & S_{KM} & K_{MK}
\end{bmatrix}
\times
\begin{bmatrix} M_{CA} \\ M_{EC} \\ M_{GE} \\ M_{IG} \\ M_{KI} \\ \theta_A \\ \theta_C \\ \theta_E \\ \theta_G \\ \theta_I \\ \theta_K \\ \theta_M \end{bmatrix}
=
\begin{bmatrix} F_{CA} \\ F_{EC} \\ F_{GE} \\ F_{IG} \\ F_{KI} \\ F_{AC} \\ F_{CE} \\ F_{EG} \\ F_{GI} \\ F_{IK} \\ F_{KM} \\ F_{MK} \end{bmatrix}
$$

EIGHT CELL MATRICES
Figure 24

NINE CELL ANALYSIS (19 span continuous structure)

Slope-deflection equations are:

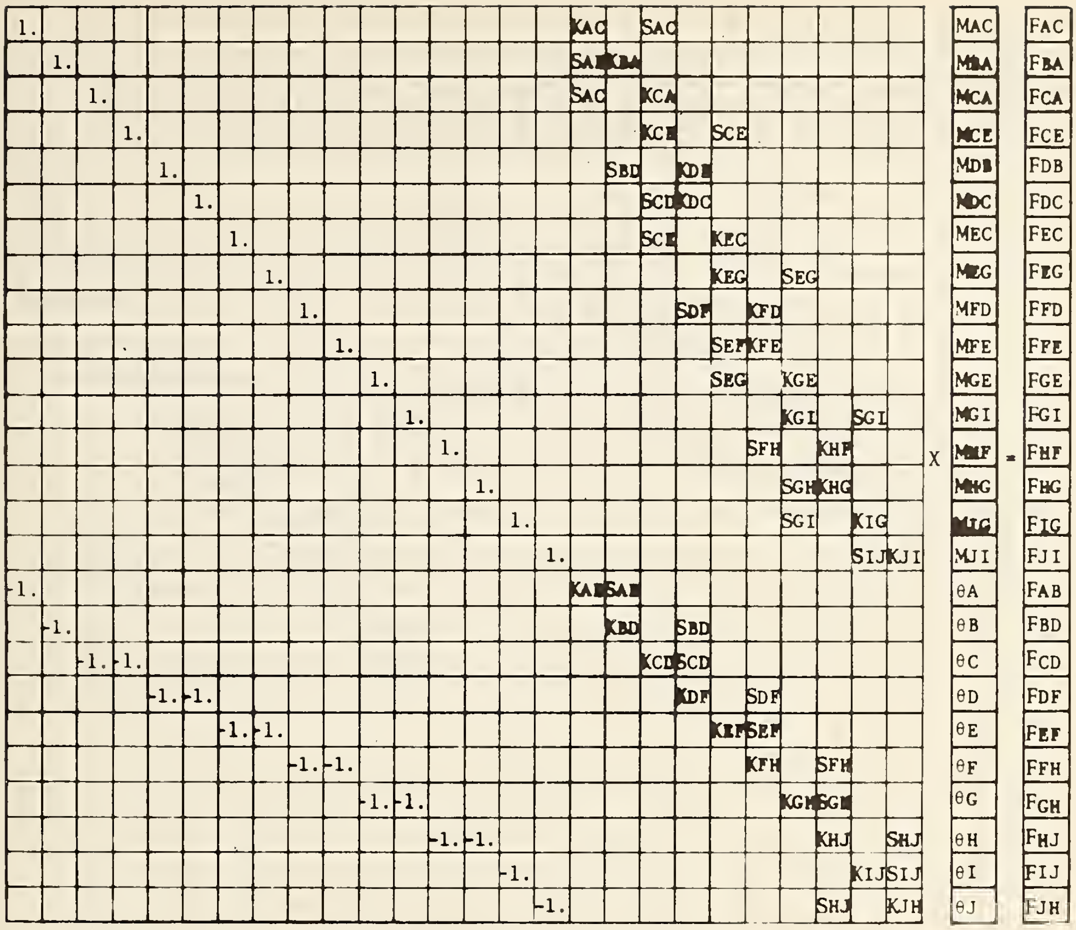
1.1 MAB = FAB - KAB x θA - CBA x KBA x θB
1.2 MBA = FBA - KBA x θB - CAB x KAB x θA
1.3 MBC = FBC - KBC x θB - CCB x KCB x θC
1.4 MCB = FCB - KCB x θC - CBC x KBC x θB
1.5 MCD = FCD - KCD x θC - CDC x KDC x θD
1.6 MDC = FDC KDC x θD - CCD x KCD x θC
1.7 MDE = FDE - KDE x θD - CED x KED x θE
1.8 MED = FED - KED x θE - CDE x KDE x θD
1.9 MEF = FEF - KEF x θE - CFE x KFE x θF
1.10 MFE = FFE - KFE x θF - CEF x KEF x θE
1.11 MFG = FFG - KFG x θF - CGF x KGF x θG
1.12 MGF = FGF - KGF x θG - CFG x KFG x θF
1.13 MGH = FGH - KGH x θG - CHG x KHG x θH
1.14 MHG = FHG - KHG x θH - CGH x KGH x θG
1.15 MHI = FHI - KHI x θH - CIH x KIH x θI
1.16 MIH = FIH - KIH x θI - CHI x KHI x θH
1.17 MIJ = FIJ - KIJ x θI - CJI x KJI x θJ
1.18 MJI = FJI - KJI x θJ - CIJ x KIJ x θI
1.19 MJK = FJK - KJK x θJ - CKJ x KKJ x θK
1.20 MKJ = FKJ - KKJ x θK - CJK x KJK x θJ
1.21 MKL = FKL - KKL x θK - CLK x KLK x θL
1.22 MLK = FLK - KLK x θL - CKL x KKL x θK
1.23 MLM = FLM - KIM x θL - CML x KML x θM
1.24 MML = FML - KML x θM - CLM x KLM x θL
1.25 MMN = FMN - KMN x θM - CNM x KNM x θN
1.26 MNM = FNM - KNM x θN - CMN x KMN x θM
1.27 MNO = FNO - KNO x θN - CON x KON x θO
1.28 MON = FON - KON x θO - CNO x KNO x θN
1.29 MOP = FOP - KOP x θO - CPO x KPO x θP
1.30 MPO = FPO - KPO x θP - COP x KOP x θO
1.31 MPQ = FPQ - KPQ x θP - CQP x KQP x θQ
1.32 MQP = FQP - KQP x θQ - CPQ x KPQ x θP
1.33 MQR = FQR - KQR x θQ - CRQ x KRQ x θR
1.34 MRQ = FRQ - KRQ x θR - CQR x KQR x θQ
1.35 MRS = FRS - KRS x θR - CSR x KSR x θS
1.36 MSR = FSR - KSR x θS - CRS x KRS x θR
1.37 MST = FST - KST x θS - CTS x KTS x θT
1.38 MTS = FTS - KTS x θT - CST x KST x θS

Statical condition equations and identities are:

2.1 MAB = Zero
2.2 MTS = Zero
2.3 MBC = Zero
2.4 MCD = - MCA
2.5 MDE = - MDC
2.6 MEF = - MED
2.7 MFG = - MFE
2.8 MGH = - MGF
2.9 MHI = - MHG
2.10 MIJ = - MIH
2.11 MJK = - MJI
2.12 MKL = - MKJ
2.13 MLM = - MLK
2.14 MMN = - MML
2.15 MNO = - MNM
2.16 MOP = - MON
2.17 MPQ = - MPO
2.18 MQR = - MQP
2.19 MRS = - MRQ
2.20 MST = - MSR

3.1 SAB = KAB x CAB = KBA x CBA
3.2 SBC = KBC x CBC = KCB x CCB
3.3 SCD = KCD x CCD = KDC x CDC
3.4 SDE = KDE x CDE = KED x CED
3.5 SEF = KEF x CEF = KFE x CFE
3.6 SFG = KFG x CFG = KGF x CGF
3.7 SGH = KGH x CGH = KHG x CHG
3.8 SHI = KHI x CHI = KIH x CIH
3.9 SIJ = KIJ x CIJ = KJI x CJI
3.10 SJK = KJK x CJK = KKJ x CKJ
3.11 SKL = KKL x CKL = KLK x CLK
3.12 SLM = KLM x CLM = KML x CML
3.13 SMN = KMN x CMN = KNM x CNM
3.14 SNO = KNO x CNO = KON x CON
3.15 SOP = KOP x COP = KPO x CPO
3.16 SPQ = KPQ x CPQ = KQP x CQP
3.17 SQR = KQR x CQR = KRQ x CRQ
3.18 SRS = KRS x CRS = KSR x CSR
3.19 SST = KST x CST = KTS x CTS

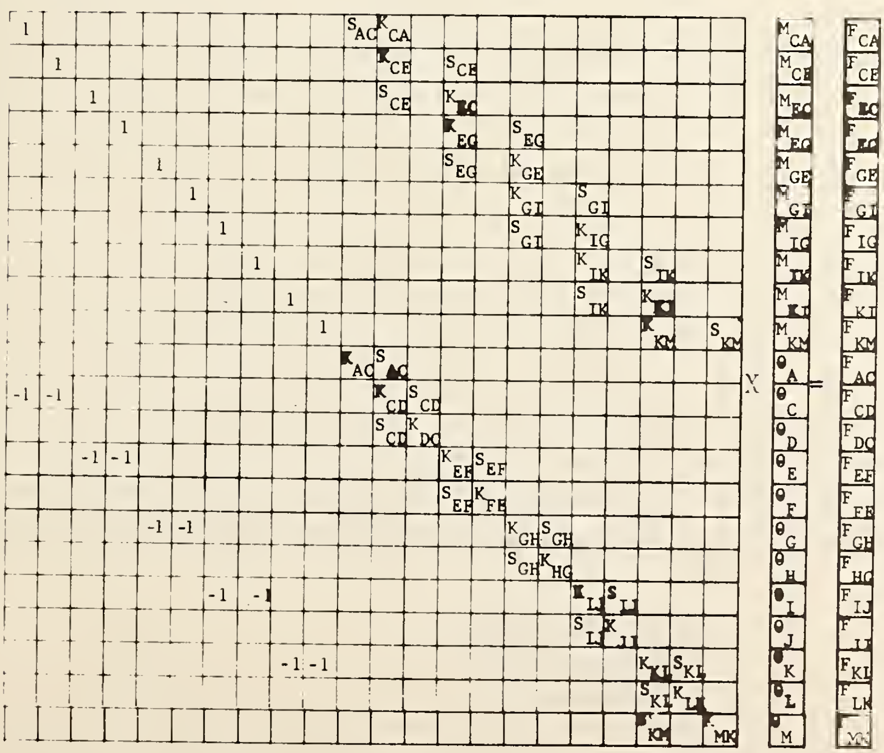
By substituting equations 2 and 3 into equation 1 and arranging into matrix form, we get the matrices displayed in Figure 29, page 56.



FOUR CELL

MATRICES

Figure 25



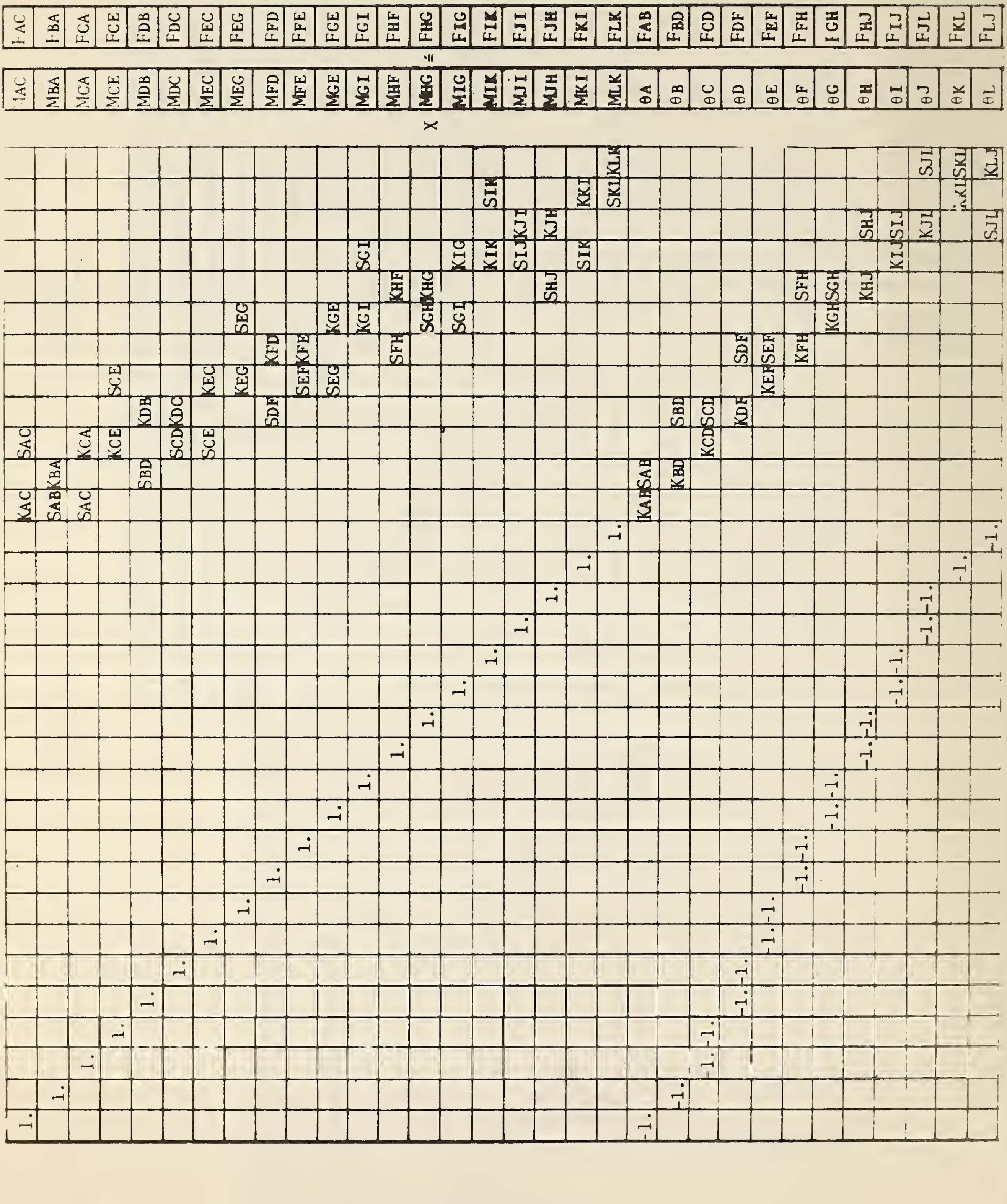
SIX SPAN

INTEGRAL

MATRICES

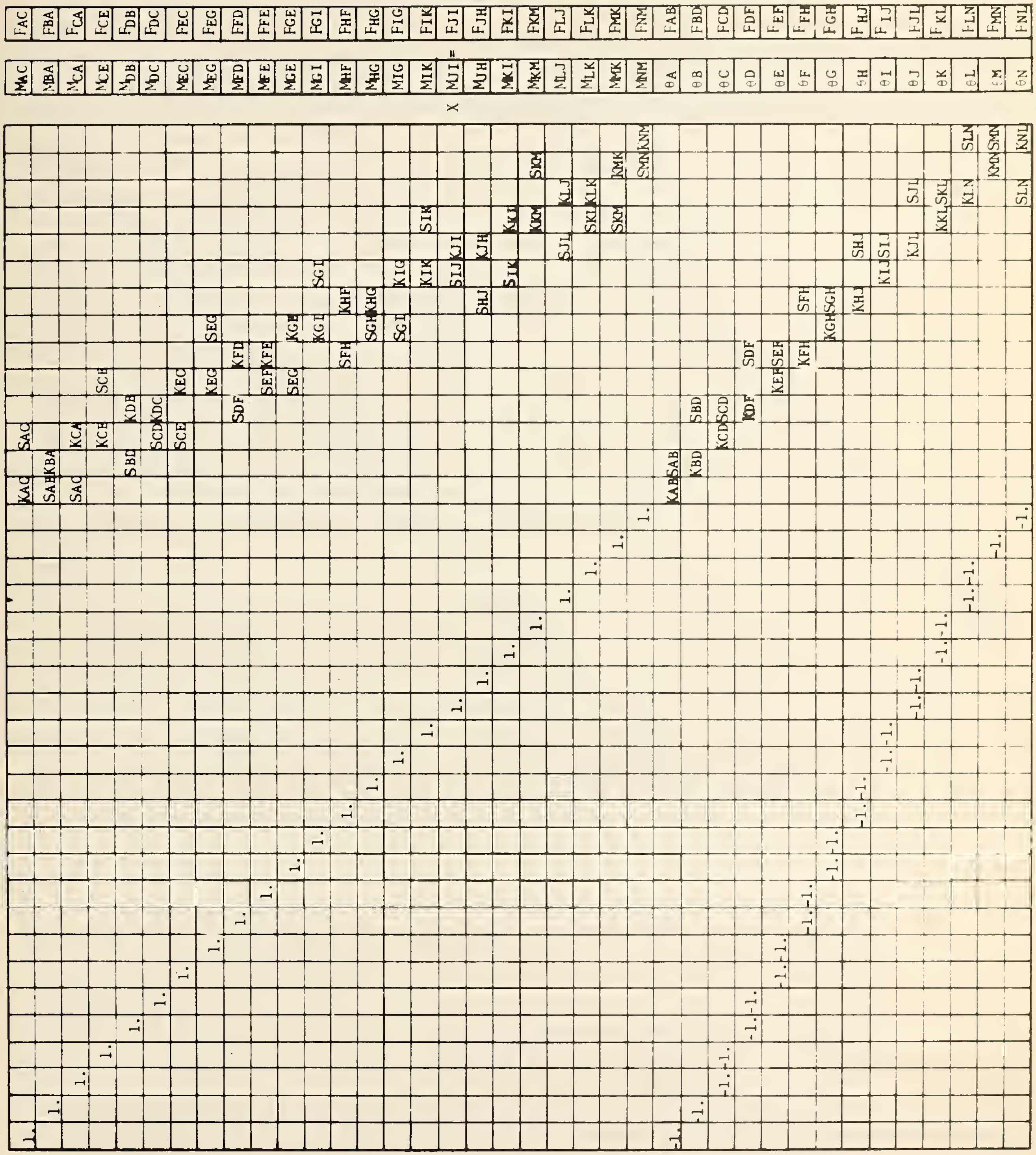
(Cell = Seven)

Figure 26



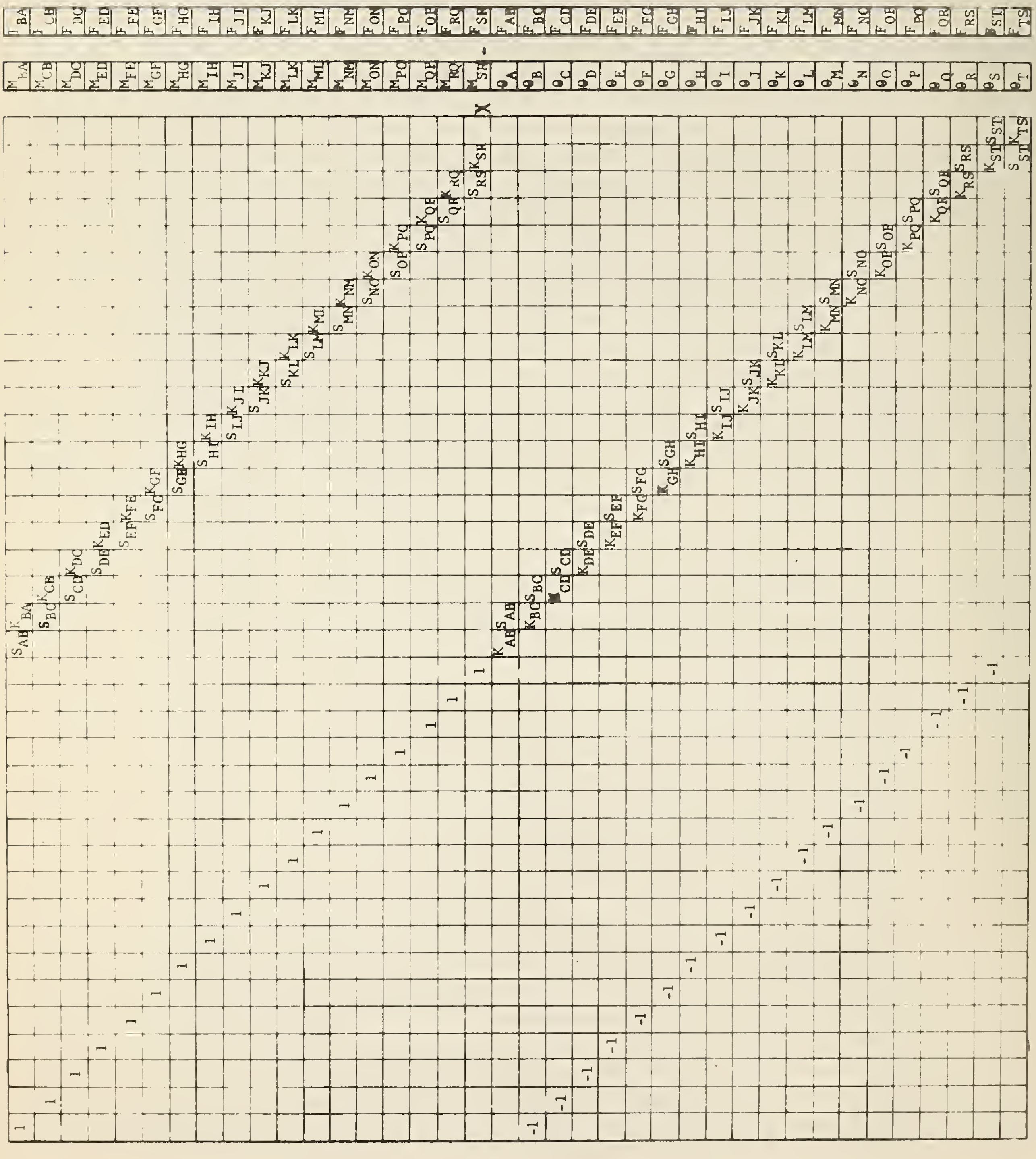
FIVE CELL MATRICES

Figure 27



SIX CELL MATRICES

Figure 28

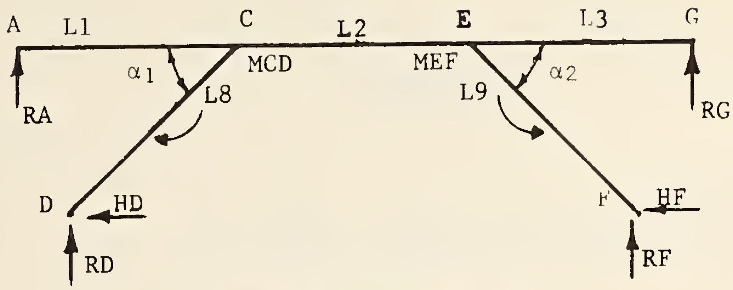


NINETEEN SPAN CONTINUOUS MATRICES

(Cell = Nine)
Figure 29

DC401A, 3 Span Slant Leg Rigid Frame Analysis

By slope-deflection method.



STRUCTURE NOMENCLATURE
Figure 30

Assumptions:

a. Pinned joints at A, D, F, and G (Moments = 0).
b. Sidesway and settlement of joint C and E are allowed.
c. No exterior horizontal reaction at A and G.
d. All members remain their original lengths.

Definitions:

MAC = Final moments at A in member AC.
FAC = Fixed end moment at A in member AC.
KAC = Stiffness at A in member AC.
CAC = Carryover factor at A in member AC.
θA = Angle joint A will rotate under loading
ρA = Angle defined by Δ/L, where Δ is the amount of translation of end of member and L = length of member.
Δ = Amount of sidesway (travel in horizontal direction).
H = Summation of horizontal reactions.
L8 = Length of member 8.

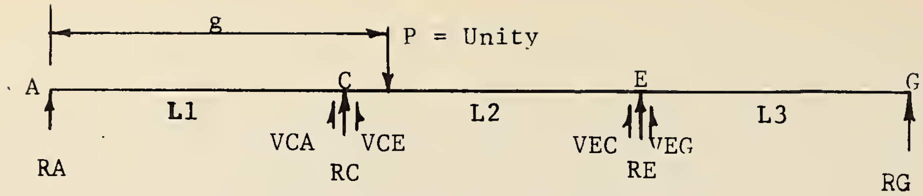
Derivations:

a. $H = HD + HF$
b. $MCD = RD \times L8 \times \cos\alpha_1 + HD \times L8 \times \sin\alpha_1$
c. $MEF = -RF \times L9 \times \cos\alpha_2 + HF \times L9 \times \sin\alpha_2$

By combining,

$$H = \frac{MCD}{L8 \times \sin\alpha_1} + \frac{MEF}{L9 \times \sin\alpha_2} - \frac{RD\cos\alpha_1}{\sin\alpha_1} + \frac{RF\cos\alpha_2}{\sin\alpha_2} \qquad \text{(Equation 1)}$$

Considering that shears (or reactions) at joints C and E cause moments in the structure, the condition equations for reactions are written.



SHEAR SKETCH
Figure 31

Condition 1

Load in Span 1. $(0 < g \leq L1)$

RC = [MCA + g]/L1 - [MCE + MEC]/L2 = RD
RD x L1 + [MCE + MEC]L1/L2 - MCA = g (Equation 2A)

RE = [MEC + MCE]/L2 - MEG/L3 = RF
RF + MEG/L3 - [MEC + MCE]/L2 = 0 (Equation 3A)

Condition 2

Load in Span 2. $(L1 < g \leq L1 + L2)$

RC = MCA/L1 - [MCE + MEC]/L2 + [L1 + L2 - g] = RD
RD x L1 + [MCE + MEC]/L1/L2-MCA=[L1+L2-g]L1/L2 (Equation 2B)

RE = -MEG/L3+[MCE+MEC]/L2+[g-L1]/L2 = RF
RF + MEG/L3-[MCE+MEC]/L2 = [g-L1]/L2 (Equation 3B)

Condition 3

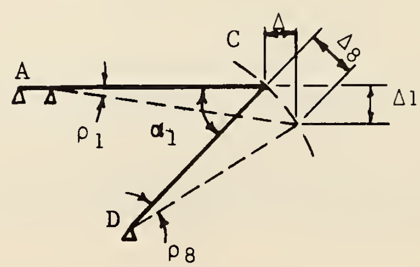
Load in Span 3. $(L1 + L2 < g \leq L1 + L2 + L3)$

RC = MCA/L1-[MCE+MEC]/L2 = RD
RD x L1+[MCE+MEC]L1/L2-MCA = 0 (Equation 2C)

RE = [MCE+MCA]/L2-MEG/L3+[L1+L2+L3-g]/L3 = RF
RF = +MEG/L3-[MCE+MEC]/L2 = L1+L2+L3-g]/L3 (Equation 3C)

Note the similarity between equations 2A, 2B and 2C and equations 3A, 3B and 3C, the only difference being on the right of the equal sign. Let the constants be designated by C1 for equations 2 and C2 for equations 3.

Allowing sidesway of the joints causes translation (ρ) of each member end. This translation can be written in terms of a horizontal displacement Δ, (called sidesway).



TRANSLATION OF SPAN 1 AND SPAN 8
Figure 32

$$\Delta_8 = \Delta/\text{Sin}\ [\alpha_1 - \rho_1/2]$$

$$\Delta_1 = \Delta\ \text{Ctn}\ [\alpha_1 - \rho_1/2]$$

$$\rho_1 = \Delta_8 360/2\pi L8 = 15\Delta_8/\pi L8 \quad \text{(L8 in ft.)}$$

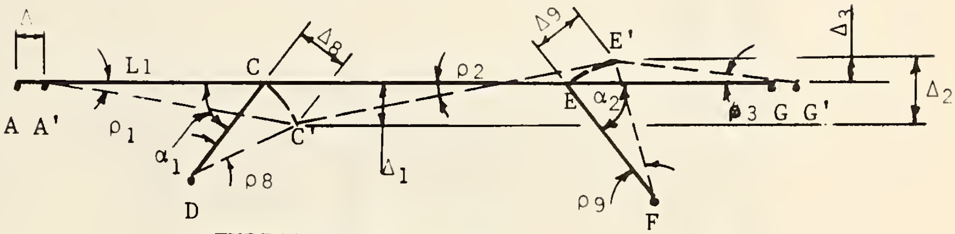
$$\alpha_1 - \rho_1/2 = \alpha_1 - 7.5\Delta_8/\pi L8 = \alpha_1 - 2.3873\Delta_8/L8$$

We see that ρ_1 is a negligible term, therefore:

$$\Delta_8 \simeq \Delta/\text{Sin}\alpha_1 \qquad \Delta_1 \simeq \Delta\ \text{Ctn}\ \alpha_1$$

$$\Delta_9 \simeq \Delta/\text{Sin}\alpha_2 \qquad \Delta_3 \simeq \Delta\ \text{Ctn}\ \alpha_2$$

$$\Delta_2 = \Delta_1 + \Delta_3 \simeq \Delta\ \text{Ctn}\ \alpha_1 + \Delta\ \text{Ctn}\ \alpha_2$$



TYPICAL TRANSLATION
Figure 33

General equations of the beams are:

1.1 $MAC = FAC - KAC\times\theta_A - CCA\times KCA\times\theta_C + \rho_1(KAC + CCA\times KCA)$

1.2 $MCA = FCA - KCA\times\theta_C - CAC\times KAC\times\theta_A + \rho_1(KCA + CAC\times KAC)$

1.3 $MCE = FCE - KCE\times\theta_C - CEC\times KEC\times\theta_E + \rho_2(KCE + CEC\times KEC)$

1.4 $MEC = FEC - KEC\times\theta_E - CCE\times KCE\times\theta_C + \rho_2(KEC + CCE\times KCE)$

1.5 $MEG = FEG - KEG\times\theta_E - CGE\times KGE\times\theta_G + \rho_3(KEG + CGE\times KGE)$

1.6 $MGE = FGE - KGE\times\theta_G - CEG\times KEG\times\theta_E + \rho_3(KGE + CEG\times KEG)$

1.7 $MCD = FCD - KCD\times\theta_C - CDC\times KDC\times\theta_D + \rho_8(KCD + CDC\times KDC)$

1.8 $MDC = FDC - KDC\times\theta_D - CCD\times KCD\times\theta_C + \rho_8(KDC + CCD\times KCD)$

1.9 $MEF = FEF - KEF\times\theta_E - CFE\times KFE\times\theta_F + \rho_9(KEF + CFE\times KFE)$

1.10 $MFE = FFE - KFE\times\theta_F - CEF\times KEF\times\theta_E + \rho_9(KFE + CEF\times KEF)$

Condition equations are:

2.1 $MCD = -(MCA + MCE)$
2.2 $MEF = -(MEC + MEG)$
2.3 $MAC = \text{Zero}$
2.4 $MDC = \text{Zero}$
2.5 $MFE = \text{Zero}$
2.6 $MGE = \text{Zero}$

Identities to be used:

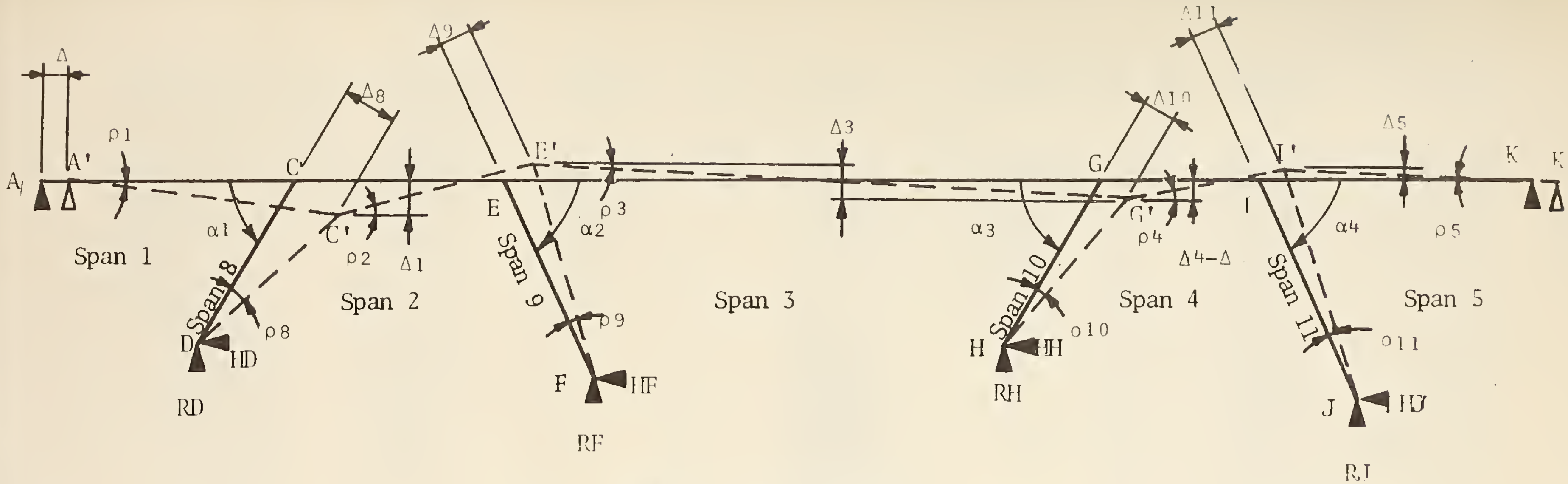
3.1 $SAC = KAC\times CAC = KCA\times CCA$
3.2 $SCE = KCE\times CCE = KEC\times CEC$
3.3 $SEG = KEG\times CEG = KGE\times CGE$
3.4 $SCD = KCD\times CCD = KDC\times CDC$
3.5 $SEF = KEF\times CEF = KFE\times CFE$

Substituting equations 2 and 3 into equations 1 and arranging into matrix form, we get the matrices displayed in Figure 34, page 60.

$\frac{1}{L_8 Sn\alpha_1}$	$\frac{1}{L_8 Sn\alpha_1}$	$\frac{1}{L_9 Sn\alpha_2}$	$\frac{1}{L_9 Sn\alpha_2}$								$-Ctn\alpha_1$	$Ctn\alpha_2$		MCA		H
	-1				KCE	SCE				$\frac{(KCE+SCE)(Ctn\alpha_1+Ctn\alpha_2)}{L_2}$				MCE		FCE
		-1			SCE	KEC				$\frac{(KEC+SCE)(Ctn\alpha_1+Ctn\alpha_2)}{L_2}$				MEC		FEC
			-1			KEG	SEG			$-\frac{(KEG+SEG)\,Ctn\alpha_2}{L_3}$				MEG		FEG
				KAC	SAC					$-\frac{(KAC\ \ SAC)\,Ctn\alpha_1}{L_1}$				θ_A		FAC
1	1				KCD			SCD		$-\frac{(KCD+SCD)}{Sin\alpha_1 L_8}$				θ_C		FCD
		1	1			KEF			SEF	$-\frac{(KEF+SEF)}{Sin\alpha_2 L_9}$			$\times$	θ_E	$=$	FEF
						SEG	KGE			$-\frac{(KGE+SEG)\,Ctn\alpha_2}{L_3}$				θ_G		FGE
					SCD			KDC		$-\frac{(KDC+SCD)}{Sin\alpha_1 L_8}$				θ_D		FDC
						SEF			KFE	$-\frac{(KFE+SEF)}{Sin\alpha_2 L_9}$				θ_F		FFE
-1				SAC	KCA					$-\frac{(KCA+SAC)\,Ctn\alpha_1}{L_1}$				Δ		FCA
$\frac{1}{L_1}$	$\frac{-1}{L_2}$	$\frac{-1}{L_2}$									-1			RD		C_1
	$\frac{1}{L_2}$	$\frac{1}{L_2}$	$\frac{-1}{L_3}$									-1		RF		C_2

THREE SPAN INTEGRAL (SLANT) LEG MATRICES

(Cell Ten)
Figure 34



STRUCTURE NOMENCLATURE
Figure 35

Basic Equations are:

1) $\Sigma H = HD + HF + HH + HJ = \Sigma$Horizontal Loads

2) $\Sigma V = RA + RD + RF + RH + RJ + RK = \Sigma$Vertical Loads

3) $MCD = -RDL8Cos\alpha 1 - HDL8Sin\alpha 1$

4) $MEF = RFL9Cos\alpha 2 - HFL9Sin\alpha 2$

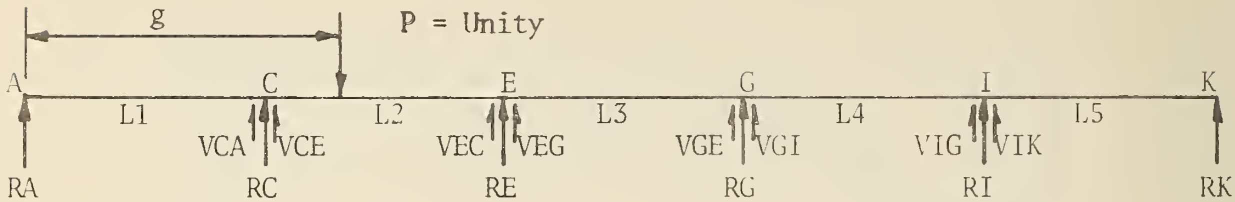
5) $MGH = -RHL10Cos\alpha 3 - HHL10Sin\alpha 3$

6) $MIJ = RJL11Cos\alpha 4 - HJL11Sin\alpha 4$

By combining equations 1, 3, 4, 5, and 6,

$$H = -\frac{MCD}{L8Sin\alpha 1} - \frac{RDCos\alpha 1}{Sin\alpha 1} - \frac{MEF}{L9Sin\alpha 2} + \frac{RFCos\alpha 2}{Sin\alpha 2} - \frac{MGH}{L10Sin\alpha 3} - \frac{RHCos\alpha 3}{Sin\alpha 3} - \frac{MIJ}{L11Sin\alpha 4} + \frac{RJCos\alpha 4}{Sin\alpha 4} \quad \text{(Equation 1)}$$

Considering that shears (or reactions) at joints C, E, G, and I cause moments in the structure, the condition equations for reactions are written.



SHEAR SKETCH
Figure 36

With

$RC = VCA + VCE = -RD$
$RE = VEC + VEG = -RF$
$RG = VGE + VGI = -RH$
$RI = VIG + VIK = -RJ$

Condition 1

And a point load in the first span $[0 \le g < L1]$,

$VCA = (MCA+g)/L1$
$VEC = (MEC+MCE)/L2$
$VGE = (MEG+MGE)/L3$
$VIG = (MGI+MIG)/L4$

$VCE = -(MCE+MEC)/L2$
$VEG = -(MEG+MGE)/L3$
$VGI = -(MGI+MIG)/L4$
$VIK = -MIK/L5$

by substitution,

$-RD = (MCA+g)/L1 - (MCE+MEC)/L2$
$-RF = (MEC+MCE)/L2 - (MEG+MGE)/L3$
$-RH = (MEG+MGE)/L3 - (MGI+MIG)/L4$
$-RJ = (MGI+MIG)/L4 - MIK/L5$

and

$-RD + (MCE+MEC)/L2 - MCA/L1 = g/L1$ (Equation 2A)
$-RF - (MEC+MCE)/L2 + (MEG+MGE)/L3 = 0$ (Equation 3A)
$-RH - (MEG+MGE)/L3 + (MGI+MIG)/L4 = 0$ (Equation 4A)
$-RJ - (MGI+MIG)/L4 + MIK/L5 = 0$ (Equation 5A)

Condition 2

Point load in Span #2 $[L1 < g < (L1+L2)]$

$VCA = MCA/L1$
$VEC = (MCE+MEC)/L2 + (g-L1)/L2$
$VGE = (MEG+MGE)/L3$
$VIG = (MGI+MIG)/L4$

$VCE = -(MCE+MEC)/L2 + (L1+L2-g)/L2$
$VEG = -(MEG+MGE)/L3$
$VGI = -(MGI+MIG)L4$
$VIK = -MIK/L5$

by substitution,

-RC = MCA/L1 - (MCE+MEC)/L2 + (L1+L2-g)/L2 = RD
-RE = (MCE+MEC)/L2 + (g-L1)/L2 - (MEG+MGE)/L3 = RF
-RG = (MEG+MGE)/L3 - (MGI+MIG)/L4 = RH
-RI = (MGI+MIG)/L4 - MIK/L5 = RJ

so

-RD + (MCE+MEC)/L2 - MCA/L1 = (L1+L2-g)/L2 (Equation 2B)
-RF + (MEG+MGE)/L3 - (MCE+MEC)/L2 = (g-L1)/L2 (Equation 3B)
-RH + (MGI+MIG)/L4 - (MEG+MGE)/L3 = 0 (Equation 4B)
-RJ + MIK /L5 - (MGI+MIG)/L4 = 0 (Equation 5B)

Condition 3

Point load on Span #3 [(L1+L2)<g<(L1+L2+L3)]

VCA = MCA/L1
VEC = (MEC+MCE)/L2
VGE = (MEG+MGE)/L3+(g-L1-L2)/L3
VIG = (MGI+MIG)/L4

VCE =-(MCE+MEC)/L2
VEG =-(MEG+MGE)/L3+(L1+L2+L3-g)/L3
VGI =-(MGI+MIG)/L4
VIK =- MIK/L5

by substitution,

-RD + (MCE+MEC)/L2 - MCA/L1 = 0 (Equation 2C)
-RF + (MEG+MGE)/L3 - (MEC+MCE)/L2 =(L1+L2+L3-g)/L3 (Equation 3C)
-RH + (MGI+MIG)/L4 - (MEG+MGE)/L3 = (g-L1-L2)/L3 (Equation 4C)
-RJ + MIK/L5 - (MGI+MIG)/L4 = 0 (Equation 5C)

Condition 4

Point load in Span #4 [(L1+L2+L3)<g<(L1+L2+L3+L4)]

VCA = MCA/L1
VEC = (MEC+MCE)/L2
VGE = (MEG+MGE)/L3
VIG = (MGI+MIG)/L4+(g-L1-L2-L3)/L4

VCE = -(MCE+MEC)/L2
VEG = -(MEG+MGE)/L3
VGI = -(MGI+MIG)/L4+(L1+L2+L3+L4-g)/L4
VIK = -MIK/L5

and

-RD + (MCE+MEC)/L2-MCA/L1 = 0 (Equation 2D)
-RF + (MEG+MGE)/L3-(MEC+MCE)/L2 = 0 (Equation 3D)
-RH + (MGI+MIG)/L4-(MEG+MGE)/L3=(L1+L2+L3+L4-g)/L4 (Equation 4D)
-RJ + MIK/L5 - (MGI+MIG)/L4 = (g-L1-L2-L3)/L4 (Equation 5D)

Condition 5

Load in Span #5 [(L1+L2+L3+L4)<g≤(L1+L2+L3+L4+L5)]

VCA = MCA/L1
VEC = (MEC+MCE)/L2
VGE = (MEG+MGE)/L3
VIG = (MIG+MGI)/L4

VCE = -(MCE+MEC)/L2
VEG = -(MEG+MGE)/L3
VGI = -(MGI+MIG)/L4
VIK = -MIK/L5 + (L1+L2+L3+L4+L5-g)/L5

and

-RD + (MCE+MEC)/L2 - MCA/L1 = 0 (Equation 2E)
-RF + (MEG+MGE)/L3 - (MEC+MCE)/L2 = 0 (Equation 3E)
-RH + (MGI+MIG)/L4 - (MEG+MGE)/L3 = 0 (Equation 4E)
-RJ + (MIK)/L5 - (MGI+MIG)/L4 = (L1+L2+L3+L4+L5-g)/L5 (Equation 5E)

Since the left sides of all equations for RD, RF, RH, and RJ are equal, these equations can be written in the following form:

TABLE OF REACTION EQUATIONS

EQUATION		Load in Span #1	Load in Span #2	Load in Span #3	Load in Span #4	Load in Span #5
-RD + MCE/L2 + MEC/L2 - MCA/L1	=	G1/L1	1-G2/L2	0	0	0
-RF + MEG/L3 + MGE/L3 - MEC/L2 - MCE/L2	=	0	G2/L2	1-G3/L3	0	0
-RH + MGI/L4 + MIG/L4 - MEG/L3 - MGE/L3	=	0	0	G3/L3	1-G4/L4	0
-RJ + MIK/L5 - MGI/L4 - MIG/L4	=	0	0	0	G4/L4	1-G5/L5

Where G1, G2, G3, G4, and G5 are distances from the left ends of the respective spans (1, 2, 3, 4, and 5) to the point load.

A horizontal displacement of joint A will cause corresponding displacements of joints C, E, G, I and K (See Figure 32). Ignoring the secondary displacement due to rotation, the displacements are:

$\Delta_1 = \Delta\ \mathrm{Ctn}\alpha_1$
$\Delta_2 = \Delta\ (\mathrm{Ctn}\alpha_1 + \mathrm{Ctn}\alpha_2)$
$\Delta_3 = \Delta\ (\mathrm{Ctn}\alpha_2 + \mathrm{Ctn}\alpha_3)$
$\Delta_4 = \Delta\ (\mathrm{Ctn}\alpha_3 + \mathrm{Ctn}\alpha_4)$
$\Delta_5 = \Delta\ \mathrm{Ctn}\alpha_4$
$\Delta_8 = \Delta\ /\mathrm{Sin}\alpha_1$
$\Delta_9 = \Delta\ /\mathrm{Sin}\alpha_2$
$\Delta_{10} = \Delta\ /\mathrm{Sin}\alpha_3$
$\Delta_{11} = \Delta\ /\mathrm{Sin}\alpha_4$

and $\rho_1 = \Delta_1/L_1 = \Delta\ \mathrm{Ctn}\alpha_1/L_1$ (Equation 6)
$\rho_2 = \Delta_2/L_2 = \Delta\ (\mathrm{Ctn}\alpha_1+\mathrm{Ctn}\alpha_2)/L_2$ (Equation 7)
$\rho_3 = \Delta_3/L_3 = \Delta\ (\mathrm{Ctn}\alpha_2+\mathrm{Ctn}\alpha_3)/L_3$ (Equation 8)
$\rho_4 = \Delta_4/L_4 = \Delta\ (\mathrm{Ctn}\alpha_3+\mathrm{Ctn}\alpha_4)/L_4$ (Equation 9)
$\rho_5 = \Delta_5/L_5 = \Delta\ \mathrm{Ctn}\alpha_4/L_5$ (Equation 10)
$\rho_8 = \Delta_8/L_8 = \Delta\ /((\mathrm{Sin}\alpha_1)L_8)$ (Equation 11)
$\rho_9 = \Delta_9/L_9 = \Delta\ /((\mathrm{Sin}\alpha_2)L_9)$ (Equation 12)
$\rho_{10} = \Delta_{10}/L_{10} = \Delta\ /((\mathrm{Sin}\alpha_3)L_{10})$ (Equation 13)
$\rho_{11} = \Delta_{11}/L_{11} = \Delta\ /((\mathrm{Sin}\alpha_4)L_{11})$ (Equation 14)

Writing slope-deflection equations for the spans:

1.1 - MAC = FAC - KAC x θA - CCA x KCA x θC - ρ1 (KAC+CCA x KCA)
1.2 - MCA = FCA - KCA x θC - CAC x KAC x θA - ρ1 (KCA+CAC x KAC)
1.3 - MCE = FCE - KCE x θC - CEC x KEC x θE + ρ2 (KCE+CEC x KEC)
1.4 - MEC = FEC - KEC x θE - CCE x KCE x θC + ρ2 (KEC+CCE x KCE)
1.5 - MEG = FEG - KEG x θE - CGE x KGE x θG - ρ3 (KEG+CGE x KGE)
1.6 - MGE = FGE - KGE x θG - CEG x KEG x θE - ρ3 (KGE+CEG x KEG)
1.7 - MGI = FGI - KGI x θG - CIG x KIG x θI + ρ4 (KGI+CIG x KIG)
1.8 - MIG = FIG - KIG x θI - CGI x KGI x θG + ρ4 (KIG+CGI x KGI)
1.9 - MIK = FIK - KIK x θI - CKI x KKI x θK - ρ5 (KIK+CKI x KKI)
1.10 - MKI = FKI - KKI x θK - CIK x KIK x θI - ρ5 (KKI+CIK x KIK)
1.11 - MCD = FCD - KCD x θC - CDC x KDC x θD - ρ8 (KCD+CDC x KDC)
1.12 - MDC = FDC - KDC x θD - CCD x KCD x θC - ρ8 (KDC+CCD x KCD)
1.13 - MEF = FEF - KEF x θE - CFE x KFE x θF - ρ9 (KEF+CFE x KFE)
1.14 - MFE = FFE - KFE x θF - CEF x KEF x θE - ρ9 (KFE+CEF x KEF)
1.15 - MGH = FGH - KGH x θG - CHG x KHG x θH - ρ10 (KGH+CHG x KHG)
1.16 - MHG = FHG - KHG x θH - CGH x KGH x θG - ρ10 (KHG+CGH x KGH)
1.17 - MIJ = FIJ - KIJ x θI - CJI x KJI x θJ - ρ11 (KIJ+CJI x KJI)
1.18 - MJI = FJI - KJI x θJ - CIJ x KIJ x θI - ρ11 (KJI+CIJ x KIJ)

Writing condition equations:

2.1 MCD = - (MCA + MCE)
2.2 MEF = - (MEC + MEG)
2.3 MGH = - (MGE + MGI)
2.4 MIJ = - (MIG + MIK)
2.5 MAC = 0
2.6 MDC = 0
2.7 MFE = 0
2.8 MHG = 0
2.9 MJI = 0
2.10 MKI = 0

Identities to be used:

3.1 SAC = CAC x KAC = CCA x KCA
3.2 SCE = CCE x KCE = CEC x KEC
3.3 SEG = CEG x KEG = CGE x KGE
3.4 SGI = CGI x KGI = CIG x KIG
3.5 SIK = CIK x KIK = CKI x KKI
3.6 SCD = CCD x KCD = CDC x KDC
3.7 SEF = CEF x KEF = CFE x KFE
3.8 SGH = CGH x KGH = CHG x KHG
3.9 SIJ = CIJ x KIJ = CJI x KJI

Substituting equations 2.1 thru 2.10, 3.1 thru 3.9 and 6 thru 14 into equations 1.1 thru 1.18, we get the equations show in matrix form in Figure 37, page 66.

DC501A, Influence Lines (Statical Moments)
DC501D, Influence Lines (End Moments, Slant Leg)

The end influence lines are derived by multiplying the inverse matrix by the fixed end moments of point loads at each tenth point of each span.

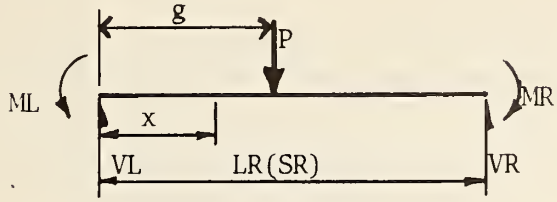
MI = FEM(L) x A(I,L) + FEM(R) x A(I,R)

Where
MI = End moment at I
FEM(L) = Fixed end moment at left end of span
FEM(R) = Fixed end moment at right end of span
A(I,L) = Coefficient of matrix for left moment
A(I,R) = Coefficient of matrix for right moment

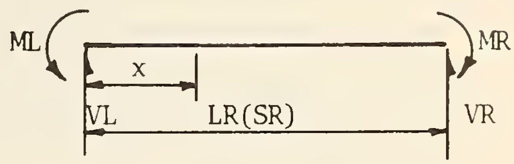
$\frac{1}{L7Sina1}$	$\frac{1}{L8Sina1}$	$\frac{1}{L9Sina2}$	$\frac{1}{L9Sina2}$	$\frac{1}{L10Sina3}$	$\frac{1}{L10Sina3}$	$\frac{1}{L11Sina4}$	$\frac{1}{L11Sina4}$											Ctna1	-Ctna2	Ctna3	-Ctna4		MCA	H
	-1								KCE		SCE											$-\frac{(KCE+SCE)(Ctna1+Ctna2)}{L2}$	MCE	FCE
		-1							CE		KEC											$-\frac{(KEC+SCE)(Ctna1+Ctna2)}{L2}$	MEC	FEC
			-1								KEG		SEG									$\frac{(KEG+SEG)(Ctna2+Ctna3)}{L3}$	MEG	FEG
				-1							SEG		KGE									$\frac{(KGE+SEG)(Ctna2+Ctna3)}{L3}$	MGE	FGE
					-1								KGI		SGI							$-\frac{(KGI+SGI)(Ctna3+Ctna4)}{L3}$	MGI	FGI
						-1							SGI		KIG							$-\frac{(KIG+SGI)(Ctna3+Ctna4)}{L4}$	MIG	FIG
							-1								KIK		SIK					$\frac{(KIK+SIK)(Ctna4)}{L5}$	MIK	FIK
								KAC	SAC													$\frac{(KAC+SAC)(Ctna1)}{L1}$	θA	FAC
-1								SAC	KCA													$\frac{(KCA+SAC)(Ctna1)}{L1}$	θC	FCA
1	1								KCD	SCD												$\frac{(KCD+SCD)}{Sina1L8}$	θD	FCD
		1	1								KEF	SEF										$\frac{(KEF+SEF)}{Sina2L9}$	θE	FEF
											SEF	KFE										$\frac{(KFE+SEF)}{Sina2L9}$	θF	FFE
				1	1								KGH	SGH								$\frac{(KGH+SGH)}{Sina3L10}$	θG	FGH
													SGH	KHG								$\frac{(KHG+SGH)}{Sina3L10}$	θH	FHG
						1	1								KIJ	SIJ						$\frac{(KIJ+SIJ)}{Sina4L11}$	θI	FIJ
															SIJ	KJI						$\frac{(KJI+SIJ)}{Sina4L11}$	θJ	FJI
															SIK		KKI					$\frac{(KKI+SIK)(Ctna4)}{L5}$	θK	FKI
$\frac{-1}{L1}$	$\frac{1}{L2}$	$\frac{1}{L2}$																-1					RD	C1
	$\frac{-1}{L2}$	$\frac{-1}{L2}$	$\frac{1}{L3}$	$\frac{1}{L3}$															-1				RF	C2
			$\frac{-1}{L3}$	$\frac{-1}{L3}$	$\frac{1}{L4}$	$\frac{1}{L4}$														-1			RH	C3
					$\frac{-1}{L4}$	$\frac{-1}{L4}$	$\frac{1}{L5}$														-1		RJ	C4
									SCD	KDC												$\frac{(KDC+SCD)}{(Sina1)L8}$	Δ	FDC

FIVE SPAN INTEGRAL (SLANT) LEG MATRICES
(Cell Eleven)
Figure 37

The shears and statical moments are calculated by two different routines. One routine is when the span is loaded, Figure 38, and the other when the span is unloaded, Figure 39. The equations for the cases are as shown below:



STATICAL LOADING
FOR LOADED SPAN
Figure 38



STATICAL LOADING
FOR UNLOADED SPAN
Figure 39

$$VL = \frac{(LR-g)P + ML + MR}{LR(SR)}$$

$VR = P - VL$

When $X \leq g$

$SMX = VL(X)SR - ML$

When $X > g$

$SMX = VL(X)SR - ML - P(X-g)SR$

$$VL = \frac{(ML + MR)}{LR(SR)}$$

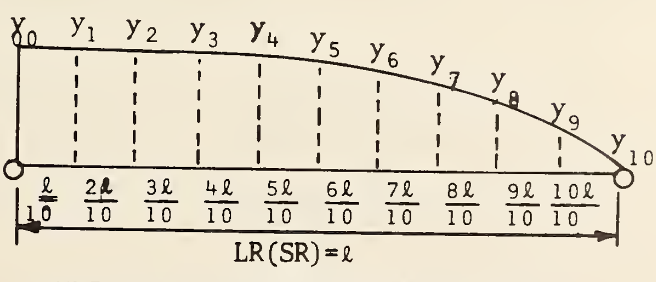
$VR = -VL$

$SMX = VL(X)SR - ML$

Where

LR = Relative span length
SR = Actual span length divided by relative span length
VR = Shear
SM = Statical Moment

DC511, Influence Areas. The areas are found by using the trapezoidal rule with increments of tenths.



TYPICAL AREA CONDITION FOR ONE SPAN
Figure 40

Dividing the plane area into 10 strips with equidistant parallel lines $y_0, y_1, \ldots y_{10}$ and with LR(SR)/10 the distance between them, then:

$$\text{Area} = \frac{LR(SR)}{10}\left[\frac{1}{2}(y_0 + y_{10}) + (y_1 + y_2 + y_3 + y_4 + y_5 + y_6 + y_7 + y_8 + y_9)\right]$$

For influence lines, LR = 1.

3.1.3 Description of Input. Description of input is given below for the data code numbers and entries that are required to execute the analysis routine.

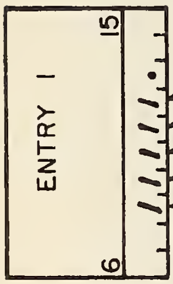
The "Work Code" entry is made only once. The "DC" tells the computer that it is a "superstructure design" program.

The "Data Code" is the name given to the heading for types of input. Cards with data codes 100 thru 110, 121 thru 124, and 131 thru 134 must be grouped together by spans; i.e., the cards for span number one must have all of the 100 thru 110, 121 thru 124, and 131 thru 134 cards listed in sequence. However, any card not needed in the sequence may be omitted.

Cards with data codes 111 thru 115 must also be listed in sequence, while any card not needed may be omitted.

a. Data Code 001 calls for entries as explained below.

Entry #1 asks for the type of output desired. By placing the number "1" in the proper space, you may request:



(1) Influence Lines
(2) Equations of Indeterminacy
(3) Beam Characteristics
(4) Beam Properties
(5) Shear Influence Lines

When a particular output is not wanted, enter a "0" in that space.

Entry #2 asks for the number of continuous spans in the structure. Counting spans is generally very straightforward; however, for the sake of clarity, each type of structure is discussed now.

(1) Piers and Abutments: (Transverse to bridge centerline). Count each span from centerline to centerline on the cap and the supports as an accumulating count of ones. The cap, of course, is counted only if the supports are fixed to it.

(2) Continuous Spans: (Longitudinal to bridge centerline). Count each continuous span and each fixed pier and/or abutment as an accumulating count of ones. Disregard whether piers and abutments are fixed at the bottom.

(3) Box Culverts: (Transverse to culvert centerline). Count each vertical and horizontal fixed span as an accumulating count of ones.

Entry #3 asks for the number of typical cross sections in the structure. In any span you have to consider each marked or major change in a horizontal or vertical dimension listed as a separate cross section. However, once a typical cross section has been counted, it will represent every other cross section that is the same, and is given a unique code number from one

thru ten. An accumulating count of ones is then made to determine all of the unlike typical cross sections for a total. Circular or round sections are not counted. Those sections that are described by use of their moments of inertia will be discussed later.

Entry #4 asks which structure layout is being used as a pattern for the structure. Put a number in this entry to select the one wanted.

0 = Cell Type Layout
9 = Continuous Type Layout
10 = Slant Leg Layout (3 Span)
11 = Slant Leg Layout (5 Span)

Cell nine is used only for structures of more than six continuous spans.

b. Data Code 100 defines the tenth points of the span at which the analysis is desired. Maximum number of points per span is eleven, with the total number that may be asked for being 209. If this card is not entered, all tenth points will be analyzed. The center of span number two (the 2.5 point) is entered as 205. When more than six points are desired, code subsequent 100 cards.

c. Data Code 101 defines general span data.

Entry #1 is the number of this span. All numbering of spans must be patterned after one of the structure layouts. Span number one of the structure must be the same as span number one of one of the structure layout types. Since every span of the structure must be described, a data code 101 card is required for each span.

Entry #2 is the length of the span measured along the member from centerline to centerline of bearing, in feet.

Entry #3 defines web range no. 1. The distance, in feet, to the first major change in the web depth going from the centerline of bearing along the member in a left to right direction is "web range no. 1".

A variation of this entry is the option to describe the member in terms of the moment of inertia. The moment of inertia, in inches^4, entered will be used in all sections of this span (Entry #5). It may be helpful to code Entry #5 before coding Entry #3.

Entry #4 defines web range no. 2. The distance, in feet, to the second major change in the web depth going from the centerline of bearing along the member in a left to right direction is "web range no. 2".

Entry #5 is the typical web case number. Five typical web cases are available to choose from in describing a member. List one of these cases (Figure 44).

Case 0 = If moment of inertia was placed in Entry #3.
Case 1 = Constant linear variation (or constant depth).
Case 2 = Linear varying to constant depth to linear varying.
Case 3 = Parabolic varying to constant depth to parabolic varying.
Case 4 = Variable section described by moments of inertia. 21 moments of inertia will be entered (if "section design" is desired, 21 distances to centroid must also be entered). See data cards 121-124 and 131-134.
Case 5 = One to four immediate depth breaks.

Entry #6 asks for the web depth at the left end. This depth is the distance between flanges or the height of a beam without flanges on the left end of a member at centerline of support, in inches. (D_1)

d. Data Code 102 is the continuation of 101 data.

Entry #1 asks for the web depth at the right end. This depth is the distance between flanges or the height of a beam without flanges on the right end of a member at centerline of support, in inches. (D_2)

Entry #2 defines the web depth at right end of left haunch or left end of right haunch. Three types of members require this entry; they are typical web case numbers two, three and five. The depth is the distance between flanges or the height of a beam without flanges at the centerline of a member, in inches. (D_3)

e. Data Code 103 thru 108. May call for a maximum of 18 cross section range entries and 18 cross section case entries per span.

Entries #1, #3 and #5 define the cross section range no. XX. These entries are the distances from centerline of bearing, going from left to right on the span, to each major change in the span cross section (excluding web depth), in feet.

The dimensions for web thickness, top flange width and thickness, and bottom flange width and thickness are calculated as uniformly varying between each cross section over the range specified. It may be seen that if a range is such that it does not include a twentieth point of the span, the effect approximates an immediate section change.

Entries #2, #4 and #6 are the respective cross section code numbers for the cross section ranges defined in the previous entries. When the designer first begins coding his program form, he should list all of his typical span cross sections and number them in order. Once a cross section has been described (111 thru 113 cards) and numbered, it may be reused anytime by simply listing its number. A total of ten typical span cross sections are allowed for each structure. If a circular section is desired, this code number will be "11".

f. Data Code 109 and 110. These cards are required only for slant leg structures and ask for the amounts of inclination of the legs. All inclinations are input as angles in degrees and decimals of degrees.

Entries #1 thru #6 of the 109 card and Entry #1 of the 110 card are angles $\beta1$ thru $\beta7$. Entries #2 and #5 of the 109 card are also used for angles $\alpha1$ thru $\alpha4$. (Figures 41 and 42)

g. Data Code 111 thru 115. These cards are used to define a typical cross section case (Figure 45). Once a typical cross section case has been described, it does not have to be described again, but may be reused by listing its number. All typical cross sections to be used, however, must be described. The cross section code for circular sections need not be entered on these cards. All dimensions are in inches.

It may be noted here that all dimensions except fillets will vary uniformly between any two typical sections.

h. Data Code 121 thru 124. Moments of inertia for twentieth points of a span are entered on these cards, in inches^4. Entries are explained on pages 77 and 78.

The moments of inertia cannot be used when rating a structure, but may be used for a design or review when the "Girder Section Design and Review" routine will not be run.

i. Data Code 131 thru 134. Distance from the bottom of the beam to the centroid of the area (Figure 45) of each twentieth point section is entered on these cards. These cards are required only if 121 thru 124 cards are entered for the span and the "Girder Section Design and Review" routine is to be run following the "Structural Loading" routine. Entries are explained on pages 78 and 79.

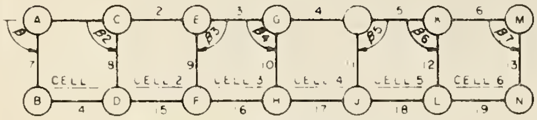
j. Data Code 401 and 402. These two cards are used when there are joints that the designer wishes to fix. By "fix", it is meant that no rotation of a joint is allowed and no moment that enters a joint is carried back to the other end of the span.

To fix a joint, the number of the span to the right of the joint is entered. Thus, to fix joint "C", the span number "2" would be entered; joint "F", enter span number "16"; joint "N", enter span number "20" (Figure 41).

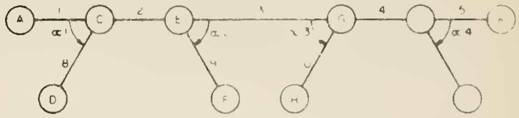
The maximum number of joints that may be fixed is seven. Span numbers 1 thru 13 are valid when fixing a joint. At any joint, only one span may frame into that joint.

Pages 73 thru 81 are prepared as summaries of the description of input. Each type of input card is portrayed with its corresponding entries and what they represent.

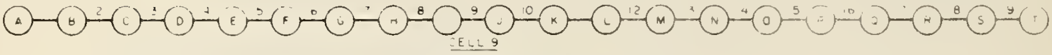
Further information on developing sections for designing and review can be found in the description of input for "Girder Section Design and Review", pages 119 and 120.



BASIC STRUCTURE - CELL LAYOUT
Figure 41

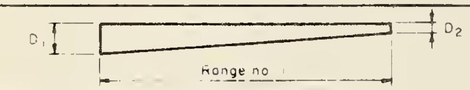
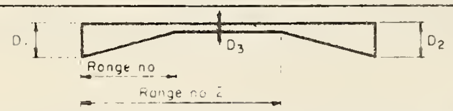
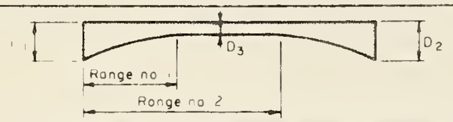
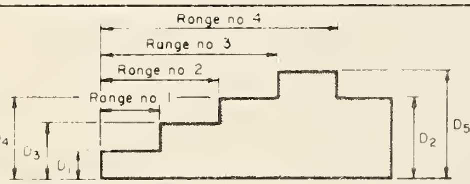


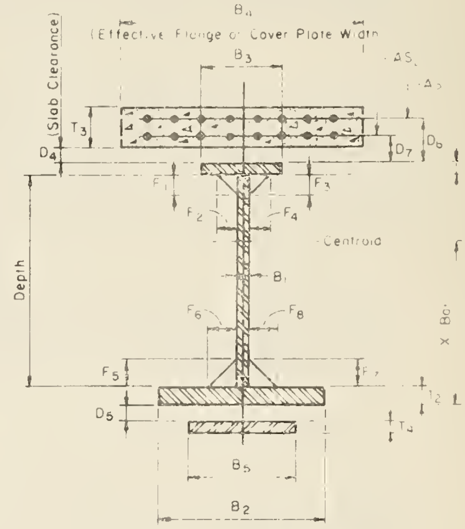
SLANT LEG LAYOUT
Figure 42



CONTINUOUS TYPE LAYOUT
Figure 43

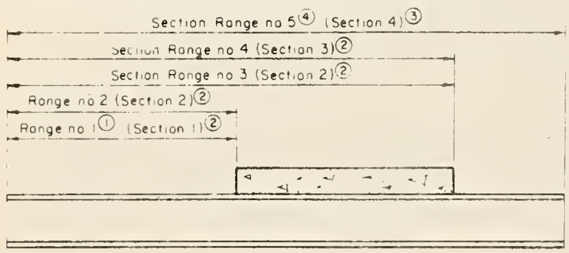
TYPICAL WEB CASES
Figure 44
(D in inches Range in feet)

Case no	Description
0	This case is used when a constant section is desired and moment of inertia is used to describe the section (inches⁴)
"1" Linear Variation	
"2" Linear Variation	
"3" Parabolic Variation	
"4"	This case is used when a variable section is desired and moment of inertia is used to describe the section. (inches⁴)
"5" Immediate Depth Break	



TYPICAL CROSS SECTION
Figure 45

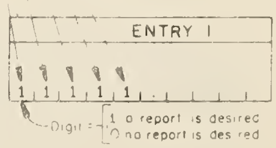
Note ① All dimensions are in inches
②10 per bridge is maximum



Note ① Dimensions for each section thru Range no 1 will be constant
② Two ranges to the same position with two different section codes denotes an immediate section change
③ Different sections between ends of the ranges will cause the web, top flange and bottom flange to be varied uniformly between their respective dimensions
④ Maximum number of ranges in one span is 18
⑤ All dimensions are in feet

TYPICAL CROSS SECTION RANGES
Figure 46

Digit	Report Title
1	SHEAR INFLUENCE LINES
2	BEAM PROPERTIES
3	BEAM CHARACTERISTICS
4	EQU OF INDETERMINACY
5	INFLUENCE LINES



OUTPUT ANSWERS
Figure 47

ENTRY 6		Point Number	Web depth at left end Inches	Web depth #5 Web case #5 only Inches
ENTRY 5		Point Number	Typical Web Case 0.=Const. Mom. of Iner. 1.=Uniform Varying 2.=Uniform Haunch 3.=Parabolic Haunch 4.=121-124 Cards to enter 5.=Immediate Break	Web range #4 Web case #5 only Feet
ENTRY 4	Basic Structure Type 0=cell type 9=7-19 span cont. 10=slant leg (3 span) 11=slant leg (5 span)	Point Number	Web Range #2 Feet	Web depth #4 Web case #5 only Inches
ENTRY 3	Number of typical cross sections in this structure. Do not include circular.	Point Number	When Case No. (Entry 5) is: 0., Enter Moment of Inertia (in.^{4}); 1, 2, 3, or 5, Enter Web Range No. 1 (ft.); 4, Leave Blank	Web range #3 Web case #5 only Feet
ENTRY 2	Number of members in this structure.	Point Number	Length of this span Feet	Web depth at right end of left haunch or left end of right haunch Inches
ENTRY 1	1 1 1 1 1 Influence Lines? Equations of Indet.? Beam Characteristic? Beam Properties? Shear Infl. Lin.?	Point Number 205.=Span #2 at 5/10 point.	Designated number of this span (corresponds to basic structure type chosen, Entry 4 on Control Card)	Web depth at right end Inches
DATA CODE	0 0 1	1 0 0 DESIGN POINTS CARD Max. No.=11 points per span. If not entered, all points will be analyzed.	1 0 1 SPAN CARD NUMBER 1 (See Figure 44)	1 0 2 SPAN CARD NUMBER 2 (Must follow a 101 card) (See Figure 44)
CARD CODE	D.C			

	Card 103	Card 104	Card 105	Card 106
ENTRY 6	Cross Section Code for Range #3 (from 1 to 10 for typical sections. Equal to '11' for Circular Sections)	Cross Section Code for Range #6 (from 1 to 10 for typical sections. Equal to '11' for Circular Sections)	Cross Section Code for Range #9 (from 1 to 10 for typical sections. Equal to '11' for Circular Sections)	Cross Section Code for Range #12 (from 1 to 10 for typical sections. Equal to '11' for Circular Sections)
ENTRY 5	Cross Section Range #3 (distance from left end to where Entry #6 cross section is typical) Feet	Cross Section Range #6 (distance from left end to where Entry #6 cross section is typical) Feet	Cross Section Range #9 (distance from left end to where Entry #6 cross section is typical) Feet	Cross Section Range #12 (distance from left end to where Entry #6 cross section is typical) Feet
ENTRY 4	Cross Section Code for Range #2 (from 1 to 10 for typical sections. Equal to '11' for Circular Sections)	Cross Section Code for Range #5 (from 1 to 10 for typical sections. Equal to '11' for Circular Sections)	Cross Section Code for Range #8 (from 1 to 10 for typical sections. Equal to '11' for Circular Sections)	Cross Section Code for Range #11 (from 1 to 10 for typical sections. Equal to '11' for Circular Sections)
ENTRY 3	Cross Section Range #2 (distance from left end to where Entry #4 cross section is typical) Feet	Cross Section Range #5 (distance from left end to where Entry #4 corss section is typical) Feet	Cross Section Range #8 (distance from left end to where Entry #4 cross section is typical) Feet	Cross Section Range #11 (distance from left end to where Entry #4 cross section is typical) Feet
ENTRY 2	Cross Section Code for Range #1 (from 1 to 10 for typical sections. Equal to '11' for Circular Sections)	Cross Section Code for Range #4 (from 1 to 10 for typical sections. Equal to '11' for Circular Sections)	Cross Section Code for Range #7 (from 1 to 10 for typical sections Equal to '11' for Circular sections)	Cross Section Code for Range #10 (from 1 to 10 for typical sections. Equal to '11' for Circular Sections)
ENTRY 1	Cross Section Range #1 (distance from left end to where Entry #2 cross section is typical) Feet	Cross Section Range #4 (distance from left end to where Entry #2 cross section is typical) Feet	Cross Section Range #7 (distance from left end to where Entry #2 cross section is typical) Feet	Cross Section Range #10 (distance from left end to where Entry #2 cross section is typical) Feet
DATA CODE	1 0 3 SPAN CARD NUMBER 3 (Must follow a 102 card)	1 0 4 SPAN CARD NUMBER 4 (Must follow a 103 card)	1 0 5 SPAN CARD NUMBER 5 (Must follow a 104 card)	1 0 6 SPAN CARD NUMBER 6 (Must follow a 105 card)
WORK CODE				

	107	108	109	110
ENTRY 6	Cross Section Code for Range #15 (from 1 to 10 for typical sections. Equal to '11' for Circular Sections)	Cross Section for Range #18 (from 1 to 10 for typical sections. Equal to '11' for Circular Sections)	Angle $\beta 6$	
ENTRY 5	Cross Section Range #15 (distance from left end to where Entry #6 cross section is typical) Feet	Cross Section Range #18 (distance from left end to where Entry #6 cross section is typical) Feet	Angle $\alpha 4$ or $\beta 5$	
ENTRY 4	Cross Section Code for Range #14 (from 1 to 10 for typical sections. Equal to '11' for Circular Sections)	Cross Section Code for Range #17 (from 1 to 10 for typical sections. Equal to '11' for Circular Sections)	Angle $\alpha 3$ or $\beta 4$	
ENTRY 3	Cross Section Range #14 (distance from left end to where Entry #4 cross section is typical) Feet	Cross Section Range #17 (distance from left end to where Entry #4 cross section is typical) Feet	Angle $\alpha 2$ or $\beta 3$	
ENTRY 2	Cross Section Code for Range #13 (from 1 to 10 for typical sections. Equal to '11' for Circular Sections)	Cross Section Code for Range #16 (from 1 to 10 for typical sections. Equal to '11' for Circular Sections)	Angle $\alpha 1$ or $\beta 2$	
ENTRY 1	Cross Section Range #13 (distance from left end to where Entry #2 cross section is typical) Feet	Cross Section Range #16 (distance from left end to where Entry #2 cross section is typical) Feet	Angle $\beta 1$	Angle $\beta 7$
DATA CODE	1 0 7 SPAN CARD NUMBER 7 (Must follow a 106 card)	1 0 8 SPAN CARD NUMBER 8 (Must follow a 107 card)	1 0 9 ANGLE OF LEGS (See Figures 41 and 42) Degrees and decimals of degrees	1 1 0 ANGLE OF LEG
WORK CODE				

	Card 1	Card 2	Card 3	Card 4
ENTRY 6	Bottom Flange Thickness (T_2) Inches	Width of Bottom Left Fillet (F_6) Inches	Ratio of modulus elasticity of steel to concrete (n). Enter a 1. if Entries #3 and #4 are for cover plates.	Area steel in composite slab (AS_2) Inches^2
ENTRY 5	Top Flange Thickness (T_1) Inches	Height of Bottom Left Fillet (F_5) Inches	Distance from top of steel flange to bottom of concrete flange or cover plate (D_4) Inches	Distance from AS_1 to top of top flange (D_6) Inches
ENTRY 4	Top Flange Width (B_3) Inches	Width of Top Right Fillet (F_4) Inches	Concrete Flange Thickness or Cover Plate (T_3) Inches	Area steel in composite slab (AS_1) Inches^2
ENTRY 3	Bottom Flange Width (B_2) Inches	Height of Top Right Fillet (F_3) Inches	Effective concrete flange width for composite girder or width of cover plate (B_4) Inches	Distance between bottom flange and bottom cover plate (D_5) Inches
ENTRY 2	Web Thickness (B_1) Inches	Width of Top Left Fillet (F_2) Inches	Width of Bottom Right Fillet (F_8) Inches	Width of Bottom Cover Plate (B_5) Inches
ENTRY 1	Cross Section Code (For cross section to be defined by these dimensions) (1 thru 10)	Height of Top Left Fillet (F_1) Inches	Height of Bottom Right Fillet (F_7) Inches	Thickness of Bottom Cover Plate (T_4) Inches
DATA CODE	1 1 1 CROSS SECTION DIMENSIONS CARD NUMBER 1 See Figure 45	1 1 2 CROSS SECTION DIMENSIONS CARD NUMBER 2 (Must follow a 111 card)	1 1 3 CROSS SECTION DIMENSIONS CARD NUMBER 3 (Must follow a 112 card)	1 1 4 CROSS SECTION DIMENSIONS CARD NUMBER 4 (Must follow a 113 card)
WORK CODE				

ENTRY 6		Moment of Inertia at 5/20 of span Inches^4	Moment of Inertia at 11/20 of span Inches^4	Moment of Inertia at 17/20 of span Inches^4
ENTRY 5		Moment of Inertia at 4/20 of span Inches^4	Moment of Inertia at 10/20 of span Inches^4	Moment of Inertia at 16/20 of span Inches^4
ENTRY 4		Moment of Inertia at 3/20 of span Inches^4	Moment of Inertia at 9/20 of span Inches^4	Moment of Inertia at 15/20 of span Inches^4
ENTRY 3		Moment of Inertia at 2/20 of span Inches^4	Moment of Inertia at 8/20 of span Inches^4	Moment of Inertia at 14/20 of span Inches^4
ENTRY 2		Moment of Inertia at 1/20 of span Inches^4	Moment of Inertia at 7/20 of span Inches^4	Moment of Inertia at 13/20 of span Inches^4
ENTRY 1	Distance from AS_2 to top of top flange (D_7) Inches	Moment of Inertia at left support Inches^4	Moment of Inertia at 6/20 of span Inches^4	Moment of Inertia at 12/20 of span Inches^4
DATA CODE	1 1 5 CROSS SECTION DIMENSIONS CARD NUMBER 5 (Must follow a 114 card) See Figure 45	1 2 1 MOMENTS OF INERTIA CARD NUMBER 1	1 2 2 MOMENTS OF INERTIA CARD NUMBER 2 (Must follow a 121 card)	1 2 3 MOMENTS OF INERTIA CARD NUMBER 3 (Must follow a 122 card)
WORK CODE				

ENTRY 6		X-Bar at 5/20 span Inches	X-Bar at 11/20 span Inches	X-Bar at 17/20 span Inches
ENTRY 5		X-Bar at 4/20 span Inches	X-Bar at 10/20 span Inches	X-Bar at 16/20 span Inches
ENTRY 4		X-Bar at 3/20 span Inches	X-Bar at 9/20 span Inches	X-Bar at 15/20 span Inches
ENTRY 3	Moment of Inertia at right support $Inches^4$	X-Bar at 2/20 span Inches	X-Bar at 8/20 span Inches	X-Bar at 14/20 span Inches
ENTRY 2	Moment of Inertia at 19/20 of span $Inches^4$	X-Bar at 1/20 span Inches	X-Bar at 7/20 span Inches	X-Bar at 13/20 span Inches
ENTRY 1	Moment of Inertia at 18/20 of span $Inches^4$	X-Bar at left support Inches	X-Bar at 6/20 span Inches	X-Bar at 12/20 span Inches
DATA CODE	1 2 4 MOMENTS OF INERTIA CARD NUMBER 4 (Must follow a 123 card)	1 3 1 DISTANCE TO CENTROID CARD NUMBER 1 (X-BAR) See Figure 45	1 3 2 DISTANCE TO CENTROID CARD NUMBER 2 (X-BAR) (Must follow a 131 card)	1 3 3 DISTANCE TO CENTROID CARD NUMBER 3 (X-BAR) (Must follow a 132 card)
WORK CODE				

	Card 1	Card 2	Card 3	Card 4
ENTRY 6		Span with fixed joint at left end		
ENTRY 5		Span with fixed joint at left end		
ENTRY 4		Span with fixed joint at left end		
ENTRY 3	X-Bar at right support Inches	Span with fixed joint at left end		
ENTRY 2	X-Bar at 19/20 span Inches	Span with fixed joint at left end		
ENTRY 1	X-Bar at 18/20 span Inches	Span with fixed joint at left end	Span with fixed joint at left end	
DATA CODE	1 3 4 DISTANCE TO CENTROID CARD NUMBER 4 (X-BAR) (Must follow a 133 card)	4 0 1 JOINT FIXITY CARD NUMBER 1	4 0 2 JOINT FIXITY CARD NUMBER 2	
WORK CODE				

SUMMARY SHEET

FORM C-16
Rev. 3/11/69

WYOMING STATE HIGHWAY DEPARTMENT
CHEYENNE WYOMING
BRIDGE DIVISION

SHEET NO. 1 OF 2
BY ______ DATE ______
CHECKED ______

//EXEC BRSYS00

DESIGN SYSTEM

Employee No.	Dept. Code	Per. D	Job Code	Work Code	Str. No.

1 COMMENT CARD

100 STRUCTURAL ANALYSIS

WORK CODE	DATA CODE	ENTRY 1	ENTRY 2	ENTRY 3	ENTRY 4	ENTRY 5	ENTRY 6	CONT
D C	0 0 1	Output Control Request (See figure 47)	Number of members in the structure	Number of typical cross sections in the structure	Structure Type (See figure 41,42,& 43)			
	1 0 0	Design point number	Design point number	Design point number	Design point number	Design point number	Design point number	
	1 0 1	Designated number of span	Length of span	Case no. (Entry #5) 0=Moment of inertia 1=Web range #1	Web range #2	Web case (See figure 44)	Web depth at left end	
	1 0 2	Web depth at right end	Web depth-right end left haunch or left end right haunch	Web range #3 (Case no. 5 only)	Web depth #4 (Case no. 5 only)	Web range #4 (Case no. 5 only)	Web depth #5 (Case no. 5 only)	
	1 0 3	Cross section range #1	Cross section code for range #1	Cross section range #2	Cross section code for range #2	Cross section range #3	Cross section code for range #3	
	1 0 4	Cross section range #4	Cross section code for range #4	Cross section range #5	Cross section code for range #5	Cross section range #6	Cross section code for range #6	
	1 0 5	Cross section range #7	Cross section code for range #7	Cross section range #8	Cross section code for range #8	Cross section range #9	Cross section code for range #9	
	1 0 6	Cross section range #10	Cross section code for range #10	Cross section range #11	Cross section code for range #11	Cross section range #12	Cross section code for range #12	
	1 0 7	Cross section range #13	Cross section code for range #13	Cross section range #14	Cross section code for range #14	Cross section range #15	Cross section code for range #15	
	1 0 8	Cross section range #16	Cross section code for range #16	Cross section range #17	Cross section code for range #17	Cross section range #18	Cross section code for range #18	
	1 0 9	Angle ∠1	Angle ∠1 or ∠2	Angle ∠2 or ∠3	Angle ∠3 or ∠4	Angle ∠4 or ∠5	Angle ∠6	
	1 1 0	Angle ∠7						
	1 1 1	Cross section code	Thickness of web (B_1)	Width of bottom flange (B_2)	Width of top flange (B_3)	Thickness of top flange (T_1)	Thickness of bottom flange (T_2)	
	1 1 2	Height of top left fillet (F_1)	Width of top left fillet (F_2)	Height of top right fillet (F_3)	Width of top right fillet (F_4)	Height of bottom left fillet (F_5)	Width of bottom left fillet (F_6)	
	1 1 3	Height of bottom right fillet (F_7)	Width of bottom right fillet (F_8)	Width of effective concrete flange or cover plate (B_4)	Thickness of conc flange or cover plate (T_3)	Distance from top of steel flange to bott of T_3 (D_4)	Modulus of elasticity ratio -- steel to concrete	
	1 1 4	Thickness of bottom cover plate (T_4)	Width of bottom cover plate (B_5)	Distance from bott flange to bottom cover plate (D_5)	Area of steel in composite slab (AS_1)	Distance from AS_1 to top of top flange (D_6)	Area of steel in composite slab (AS_2)	
	1 1 5	Distance from AS_2 to top of top flange (D_7)						
	1 2 1	Moment of inertia at left support	Moment of inertia at 1/20 point of span	Moment of inertia at 2/20 point of span	Moment of inertia at 3/20 point of span	Moment of inertia at 4/20 point of span	Moment of inertia at 5/20 point of span	
	1 2 2	Moment of inertia at 6/20 point of span	Moment of inertia at 7/20 point of span	Moment of inertia at 8/20 point of span	Moment of inertia at 9/20 point of span	Moment of inertia at 10/20 point of span	Moment of inertia at 11/20 point of span	
	1 2 3	Moment of inertia at 12/20 point of span	Moment of inertia at 13/20 point of span	Moment of inertia at 14/20 point of span	Moment of inertia at 15/20 point of span	Moment of inertia at 16/20 point of span	Moment of inertia at 17/20 point of span	

TRAILER CARD

NOTE: A trailer card must follow the last structure card containing data

Figure 48

SUMMARY SHEET

FORM C-16
Rev. 3/11/69

WYOMING STATE HIGHWAY DEPARTMENT
CHEYENNE WYOMING
BRIDGE DIVISION

DESIGN SYSTEM

SHEET NO 2 OF 2
BY ______ DATE ______
CHECKED ______

//EXEC BRSYSØØ

1 COMMENT CARD

WORD CODE (1–2)	DATA CODE (3–5)	ENTRY 1 (6–15)	ENTRY 2 (16–25)	ENTRY 3 (26–35)	ENTRY 4 (36–45)	ENTRY 5 (46–55)	ENTRY 6 (56–65)	CONT (66)
	1 2 4	Moment of inertia at 18/20 point of span	Moment of inertia at 19/20 point of span	Moment of inertia at right support				
	1 3 1	Distance to centroid, X-Bar, at left support	Distance to centroid, X-Bar, at 1/20 point of span	Distance to centroid, X-Bar, at 2/20 point of span	Distance to centroid, X-Bar, at 3/20 point of span	Distance to centroid, X-Bar, at 4/20 point of span	Distance to centroid, X-Bar, at 5/20 point of span	
	1 3 2	Distance to centroid, X-Bar, at 6/20 point of span	Distance to centroid, X-Bar, at 7/20 point of span	Distance to centroid, X-Bar, at 8/20 point of span	Distance to centroid, X-Bar, at 9/20 point of span	Distance to centroid, X-Bar, at 10/20 point of span	Distance to centroid, X-Bar, at 11/20 point of span	
	1 3 3	Distance to centroid, X-Bar, at 12/20 point of span	Distance to centroid, X-Bar, at 13/20 point of span	Distance to centroid, X-Bar, at 14/20 point of span	Distance to centroid, X-Bar, at 15/20 point of span	Distance to centroid, X-Bar, at 16/20 point of span	Distance to centroid, X-Bar, at 17/20 point of span	
	1 3 4	Distance to centroid, X-Bar, at 18/20 point of span	Distance to centroid, X-Bar, at 19/20 point of span	Distance to centroid, X-Bar, at right support				
	4 0 1	Span with fixed joint at left end	Span with fixed joint at left end	Span with fixed joint at left end	Span with fixed joint at left end	Span with fixed joint at left end	Span with fixed joint at left end	
	4 0 2	Span with fixed joint at left end						

TRAILER CARD

999

NOTE: A trailer card must follow the last structure card containing data

Figure 49

3.1.4 Description of Output. The output consists of the following reports:

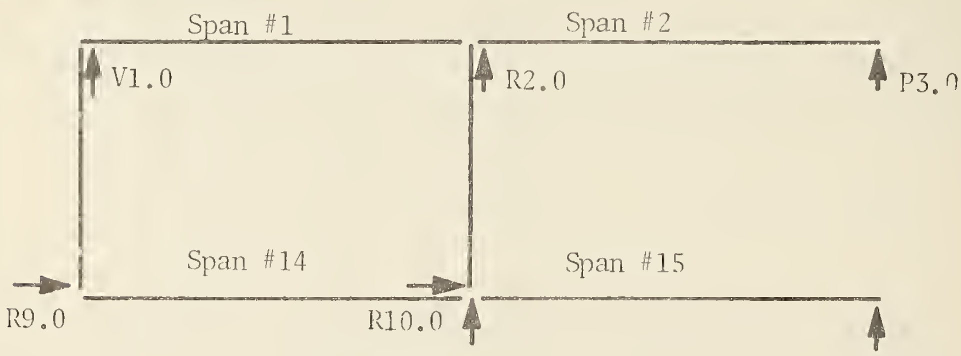
a. Beam Properties
b. Beam Characteristics
c. Indeterminate Coefficients
d. Influence Lines

Beam properties and beam characteristics may be printed out as separate reports or may be combined into one report per span, as asked for.

Indeterminate coefficients are a group of values that allow a designer to distribute moments in his structure without the time-consuming labor of moment distribution.

The influence lines come with fully documented arrays of coefficients. The influence lines for shear and moments for the left half of the span are printed first and then those for the right half are printed.

As output, reactions and shears are always perpendicular to the member. Figure 50 indicates their relative positions on each member type.



POSITIONING OF REACTIONS
Figure 50

On slant leg structures, reactions 9.0 and 10.0 do not represent horizontal forces, except in the special case where $\alpha_1=\alpha_2=\alpha_3=\alpha_4=90°$. Therefore, one must use a free body diagram to calculate HD, HF, HH, and HJ. It can be shown that:

$$HD = V9.0L \; \frac{(\sin\alpha_1+\cos^2\alpha_1)}{\sin\alpha_1} + RD \frac{\cos\alpha_1}{\sin\alpha_1}$$

Where RD = R2.0 + weight of Span #8.

$$HF = V10.0L \; \frac{(\sin\alpha_2+\cos^2\alpha_2)}{\sin\alpha_2} - RF \frac{\cos\alpha_2}{\sin\alpha_2}$$

Where RF = R3.0 + weight of Span #9.

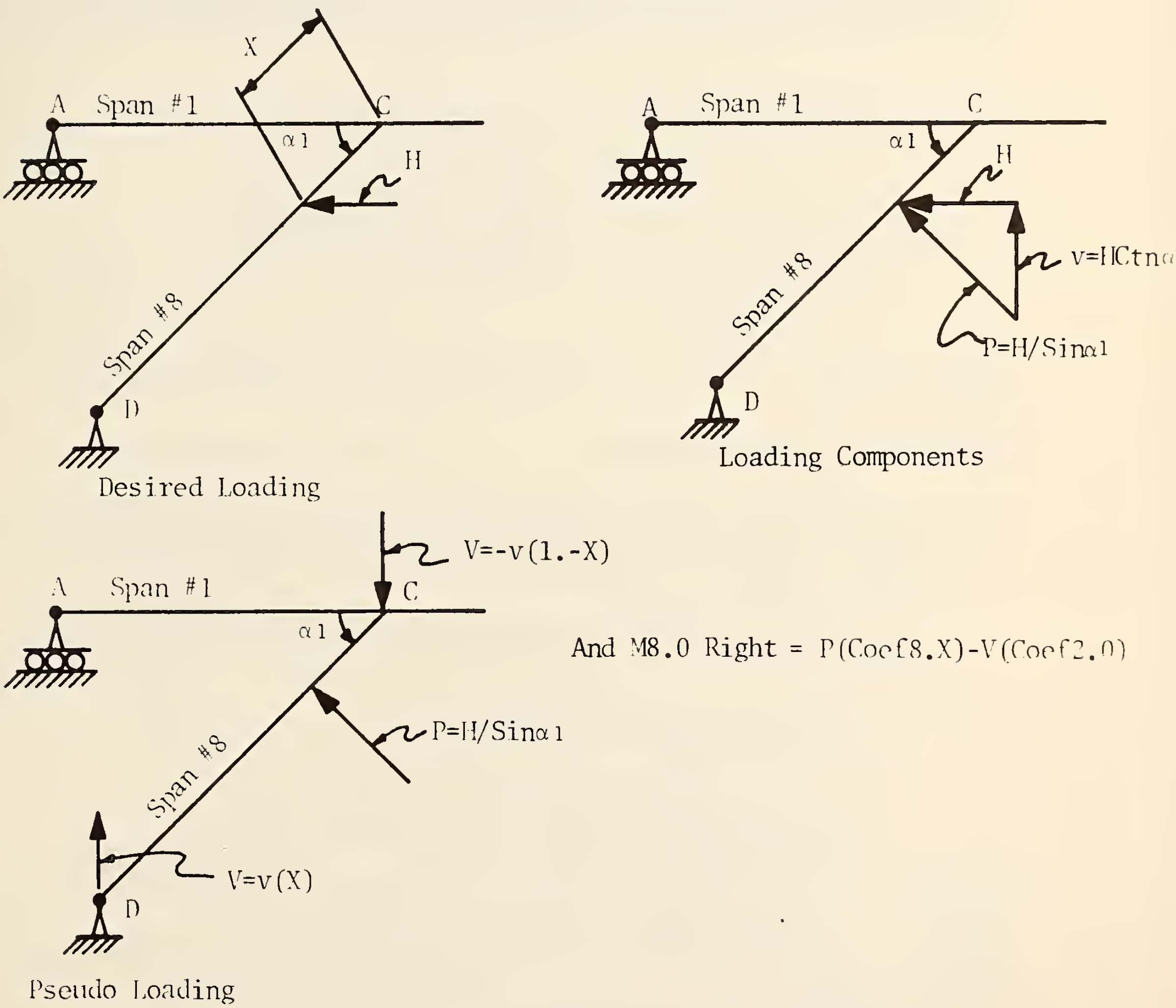
$$HH = V11.0L \; \frac{(\sin\alpha_3+\cos^2\alpha_3)}{\sin\alpha_3} + RH \frac{\cos\alpha_3}{\sin\alpha_3}$$

Where RH = R4.0 + weight of Span #10.

$$HJ = V12.0L \frac{(Sin\alpha 4 + Cos^2\alpha 4)}{Sin\alpha 4} - RJ \frac{Cos\alpha 4}{Sin\alpha 4}$$

Where RH = R5.0 + weight of Span #11.

When a horizontal force is applied to a slant leg structure, one must remember the the influence line coefficients are for loads perpendicular to the leg. The horizontal force desired must, therefore, be resolved into components. Figure 51 depicts the application of a horizontal force at a distance "X" on Span #8.



And M8.0 Right = P(Coef8.X)-V(Coef2.0)

HORIZONTAL FORCE DETERMINATION
Figure 51

3.2 Structural Loading

3.2.1 General Information. This group of programs take the influence lines created by the "Structural Analysis" subsystem and the loadings specified by the designer and calculates the moments, shears, reactions and deflections for each tenth point of each top span.

The loadings are of two types, the first being static loading, where the magnitude and position of the load is entered by the designer. Static loading may be either uniform in nature or point loads.

The second type of loading is live loading, where only the magnitude and spacing of the load is given by the designer. Live loads consist of point loads at a specified distance apart or uniform loading with a point load. The American Association of State Highway Officials (AASHO) type loading may easily be duplicated and the military loading is preset and only needsto be asked for.

There are basically five types of output and they are:

a. Static load moments, shears and reactions.
b. Live load moments, shears and reactions.
c. Deflections due to static and live loads.
d. Influence lines for deflections.
e. Maximum positive and negative moments, shears, reactions and deflections.

It is possible to request any or all of these reports on any given computer run.

Ranges and restrictions are:

a. Maximum number of superimposed static point loads is 72. These loads must be entered in the order they appear from the first support of the structure.

b. Maximum number of superimposed static uniform loads per span is one.

c. No restrictions on span lengths.

d. Maximum number of truck wheel loads is 24.

e. Minimum number of truck wheel loads is one.

f. Maximum number of uniform lane loads is one per structure.

g. Maximum number of point loads for positive moment lane loading is one.

h. Maximum number of point loads for negative moment lane loading is two. (These two point loads must not both be in the same span.)

i. Distance between front and center truck wheels for an AASHO HS loading is fixed at the spacing specified.

j. Distance between center and rear truck wheel for an AASHO HS loading may vary. There is no program restriction as to the maximum and minimum rear wheel spacing.

k. There are no restrictions on wheel spacings for the general vehicle (maximum of 24 truck wheel loads).

l. All ranges and restrictions for the "Structural Analysis" subsystem apply.

m. When deflections are calculated by "Card Input", deflections may be solved for only one span at a time.

3.2.2 Mathematical Equations and Derivations. Deflections. The deflections computed are those resulting from flexural strains.[3]

Data that is input consists of influence lines for moment at each tenth point of each span, moments of inertia for each twentieth point of each span, dead load moments and the modulus of elasticity of the girder material.

The basic formula is for the internal virtual work resulting from flexural strains.

$$\Delta y = \int_0^l \frac{Mxz\,(mxy)\,dx}{E\,I_x} \qquad \text{(Equation 1)}$$

Where Mxz = moment at x due to a unit real load at z

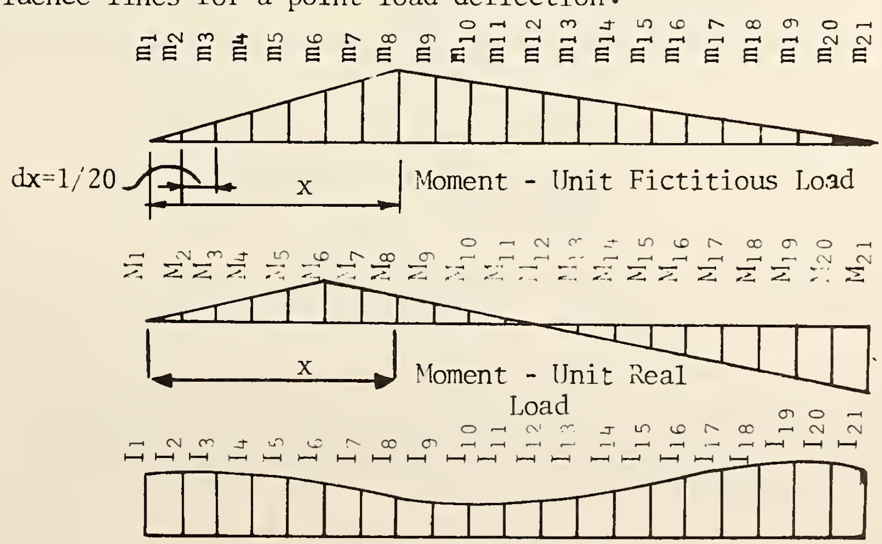
dx = increment of the span length

E = modulus of elasticity of the material

I_x = moment of inertia of the cross section at x

mxy = moment at x due to a unit fictitious load at y (simple beam moment)

Figure 52 depicts the loading conditions for the derivation of the influence lines for a point load deflection.



Moments of Inertia

DEFLECTION DIAGRAM - POINT LOAD
Figure 52

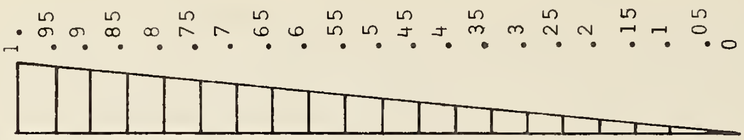
[3]Ibid, page 104

Using equation 1 and numerical integration,

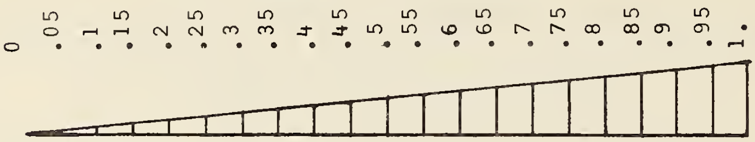
$$\Delta y = \sum_{x=1}^{x=21} \frac{Mxz\,(mxy)\,dx}{EI_x} \qquad \text{(Equation 2)}$$

and the influence line for deflection at point x is built by incrementing through the influence lines for Mxz with the same line mxy.

Deflections for a unit moment at each end of the span use the same equation (Equation 2) that was used for point loads. The only difference is in Mxz, as shown in Figure 53.



Unit Moment at Left End

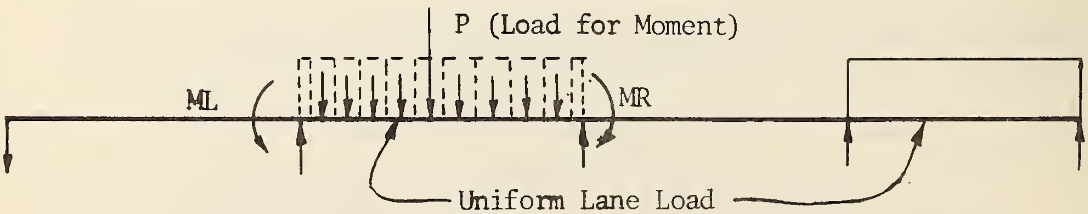


Unit Moment at Right End

DEFLECTION DIAGRAM - END MOMENT
Figure 53

Calculations for dead load deflections are the same as for other deflections, with Mxz being the actual dead load moment for the span.

Live Loading for Deflections. Point load deflection influence lines are loaded by positioning the various wheel loads and their associated wheel spacings in such a manner as to create the maximum deflection.



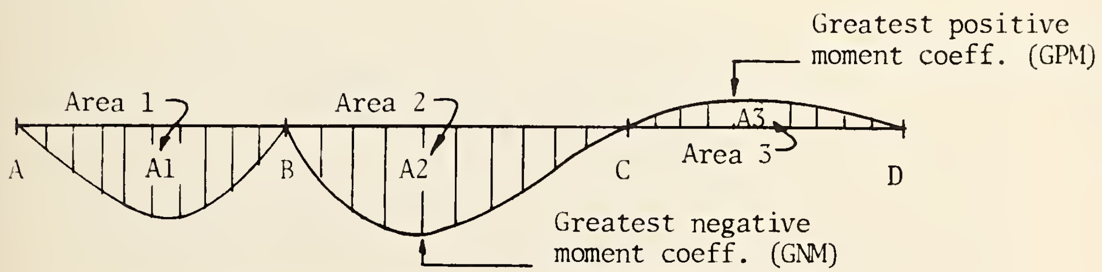
LANE LOAD
Figure 54

Lane loading uses three different influence lines to solve for the maximum deflection of a point.

Moment influence lines are loaded with uniform loads on every other span away from the span that the deflection being solved for lies in. This produces end moments for the right and left ends of the span. These end moments are converted to deflections by multiplying by the unit moment coefficients for each end.

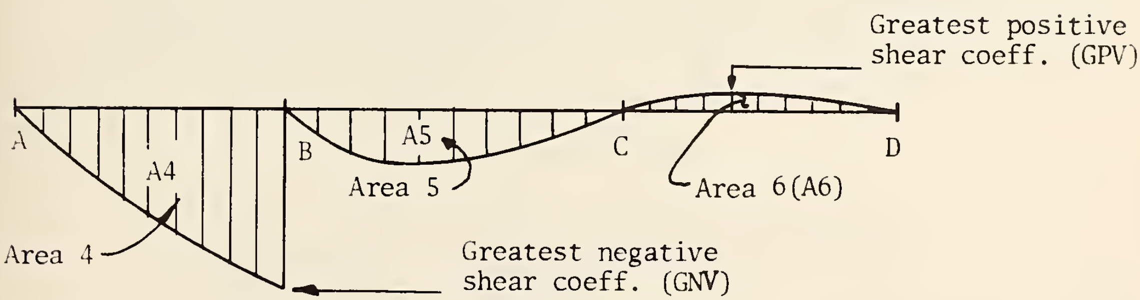
The span in which the deflection point lies is loaded with a simulated uniform load, which is broken into ten point loads. These tenth point loads and the concentrated load for moment are placed on the point load deflection influence lines in order to create the greatest deflection due to lane loading. (See Figure 54 for orientation of lane loading for deflection at the 2.5 point of a four span bridge).

Live Load Moments, Shear and Reactions. Live load moments, shears and reactions are computed by loading the appropriate influence lines with the various loading conditions in such a manner as to obtain the maximum positive and negative values for each defined point on the structure. Since the influence lines, and their areas, have already been computed and stored on disk, the following derivations will consist of methods of loading influence lines to obtain maximum values.



INFLUENCE LINE FOR MOMENT AT B

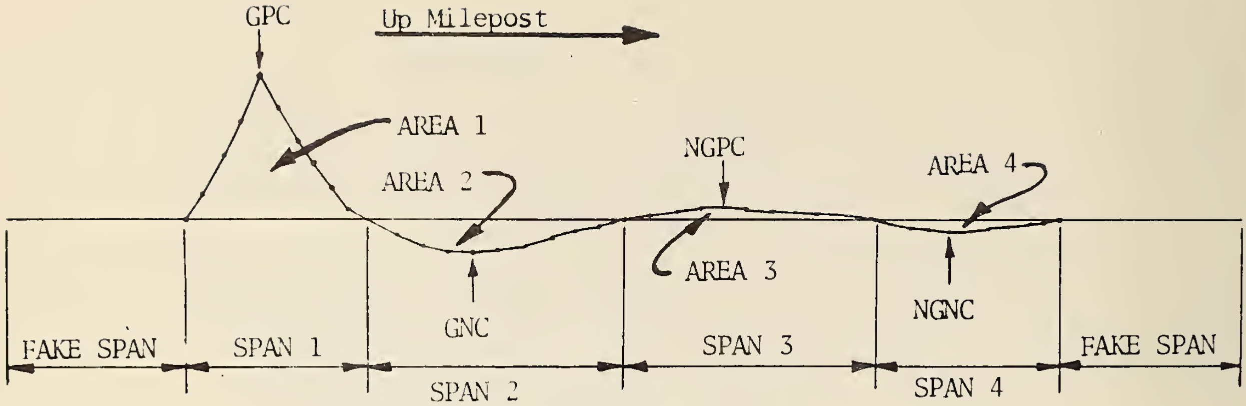
FIGURE 55



INFLUENCE LINE FOR SHEAR AT B (Left)

FIGURE 56

Derivation of Live Loading Equations

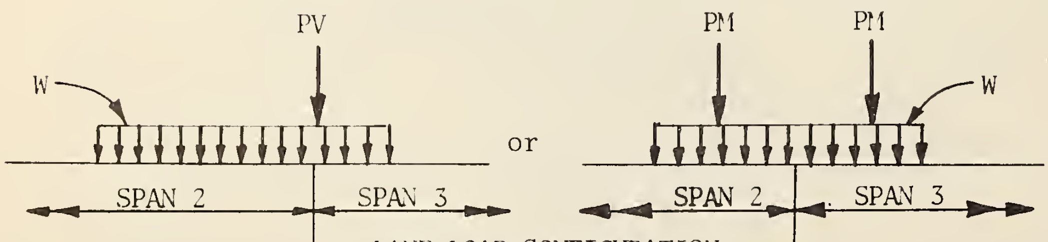


TYPICAL INFLUENCE LINE
Figure 57

Where

RSL = reference span length = span 1
PAREA = total positive area under line = AREA 1 + AREA 3
NAREA = total negative area under line = AREA 2 + AREA 4
GPC = greatest positive coefficient on line
GNC = greatest negative coefficient on line
NGPC = next greatest positive coefficient in a span other than that which GPC is in
NGNC = next greatest negative coefficient in a span other than that which GNC is in

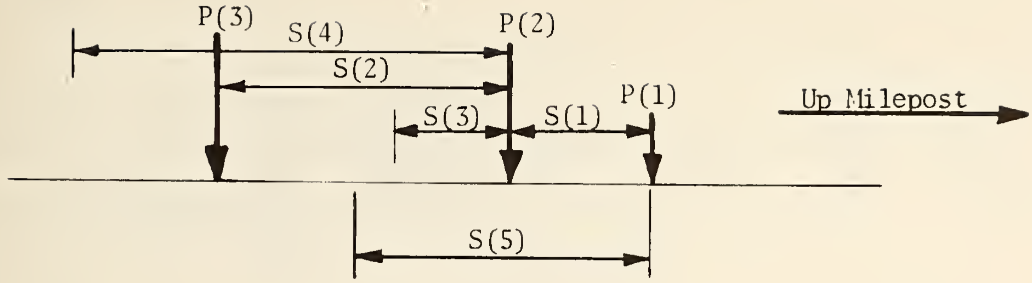
As an example of live loading techniques, an influence line for a four span bridge and the moment at the 1.4 point has been chosen, as it best represents the loading principles. Other lines for other points, shears, or reactions are only minor variations from this principle. Therefore, all further reference to an influence line will be made to Figure 57. The live loading truck load configurations are represented in Figures 58 thru 62.



LANE LOAD CONFIGURATION
Figure 58

Where

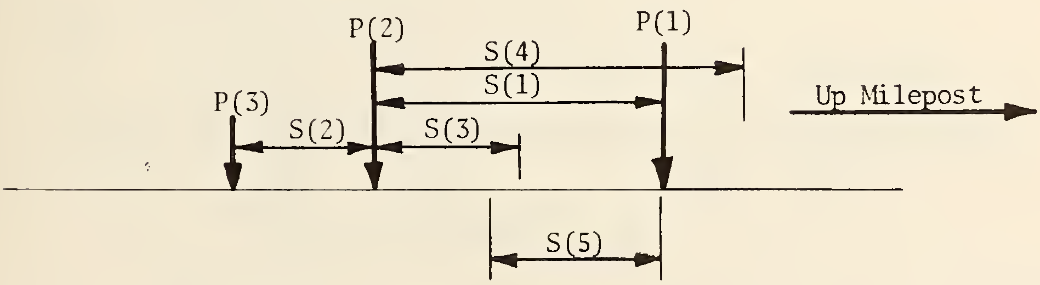
W = uniform lane load
PV = concentrated load for shear
PM = concentrated load for moment



HS TRUCK LOAD CONFIGURATION (GOING UP MILEPOST)
Figure 59

Where

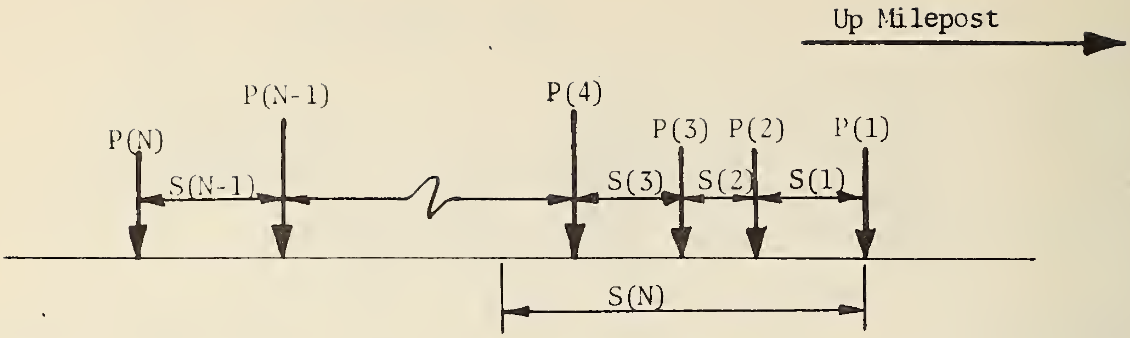
P(1) = concentrated load, front truck wheel
P(2) = concentrated load, center truck wheel
P(3) = concentrated load, rear truck wheel
S(1) = wheel spacing between P(1) and P(2)
S(2) = wheel spacing between P(2) and P(3)
S(3) = minimum spacing between P(2) and P(3)
S(4) = maximum spacing between P(2) and P(3)
S(5) = distance from P(1) to the centroid of all wheel loads



HS TRUCK LOAD CONFIGURATION (GOING DOWN MILEPOST)
Figure 60

Where

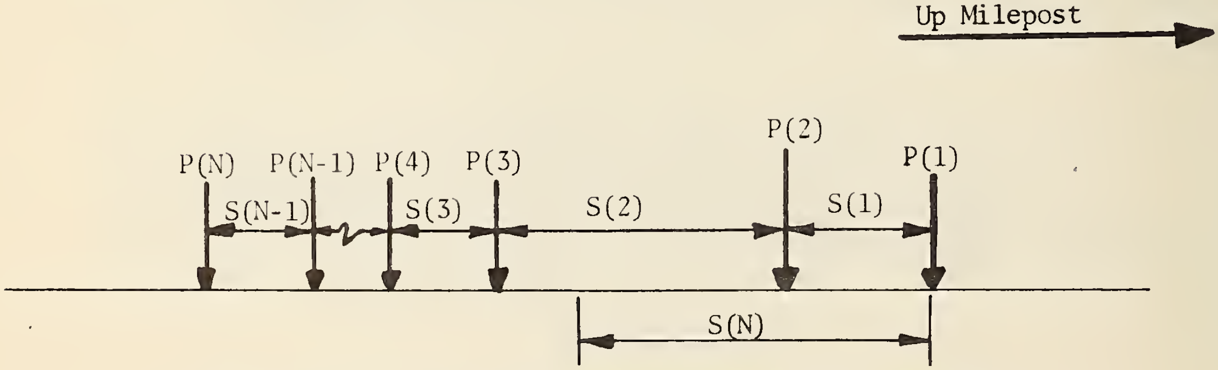
P(1) = concentrated load, rear truck wheel
P(2) = concentrated load, center truck wheel
P(3) = concentrated load, front truck wheel
S(1) = wheel spacing between P(1) and P(2)
S(2) = wheel spacing between P(2) and P(3)
S(3) = minimum spacing between P(1) and P(2)
S(4) = maximum spacing between P(1) and P(2)
S(5) = distance from P(1) to the centroid of all wheel loads



SPECIAL TRUCK LOAD CONFIGURATION (GOING UP MILEPOST)
Figure 61

Where

P(1) = concentrated load, front truck wheel
P(N) = concentrated load, rear truck wheel
N = number of truck wheel loads, between 1 and 24
S(1) = wheel spacing between front and second wheel
S(N-1) = wheel spacing between next to last and rear wheel
S(N) = distance from P(1) to the centroid of all wheel loads



SPECIAL TRUCK LOAD CONFIGURATION (GOING DOWN MILEPOST)
Figure 62

Where

P(1) = concentrated load, rear truck wheel
P(N) = concentrated load, front truck wheel
N = number of truck wheel loads, between 1 and 24
S(1) = wheel spacing between next to last and rear wheel
S(N-1)=wheel spacing between front and second wheel
S(N) = distance from P(1) to the centroid of all wheel loads

Lane loading equations are as follows:

Where

MPM = maximum positive moment
MNM = maximum negative moment
MPV = maximum positive shear
MNV = maximum negative shear
MPR = maximum positive reaction
MNR = maximum negative reaction
WFR = wheel fraction

Then,

MPM = [(PAREA) (W) (RSL)^2+ (PM) (GPC) (RSL)] (IMPACT) (WFR)
MNM = [(NAREA) (W) (RSL)^2+ (PM) (GNC+NGNC) (RSL)] (IMPACT) (WFR)
MPV = [(PAREA) (W) (RSL) + (PV) (GPC)] (IMPACT) (WFR)
MNV = [(NAREA) (W) (RSL) + (PV) (GNC)] (IMPACT) (WFR)
MPR = [(PAREA) (W) (RSL) + (PV) (GPC)] (IMPACT) (WFR)
MNR = [(NAREA) (W) (RSL) + (PV) (GNC)] (IMPACT) (WFR)

HS or special truck loading equations are as follows:

Where

SAVE(K) = array to save values of the summation of the P values times their respective influence line coefficients due to the location of the loads
K = number of positions a truck is placed on in order to obtain a maximum loading = 4(N+1)
GPSUM = greatest positive sum of P loads times coefficients
GNSUM = greatest negative sum of P loads times coefficients

Following is the sequence of steps for placing each truck loading on each influence line:

a. P(1) is placed over GPC.
b. P(1) and all other wheel loads are multiplied by the respective interpolated[1] influence line coefficients under the wheel loads.
c. The summation of loads times coefficients is set equal to SAVE(K).
d. P(2) is placed over GPC and steps two and three are repeated.
e. All P loads up thru P(N) repeat steps one, two and three.
f. The centroid of the loading group is then placed over GPC and steps two and three are repeated.
g. Steps one thru six are then repeated for GNC, NGPC, and NGNC.
h. Array SAVE(K) is then searched and the greatest positive and negative values are set equal to GPSUM and GNSUM respectively.

Then,

MPM = (GPSUM) (RSL) (IMPACT) (WFR)　　MNV = (GNSUM) (IMPACT) (WFR)

[1]All interpolation is straight line interpolation between tenth points on the influence line.

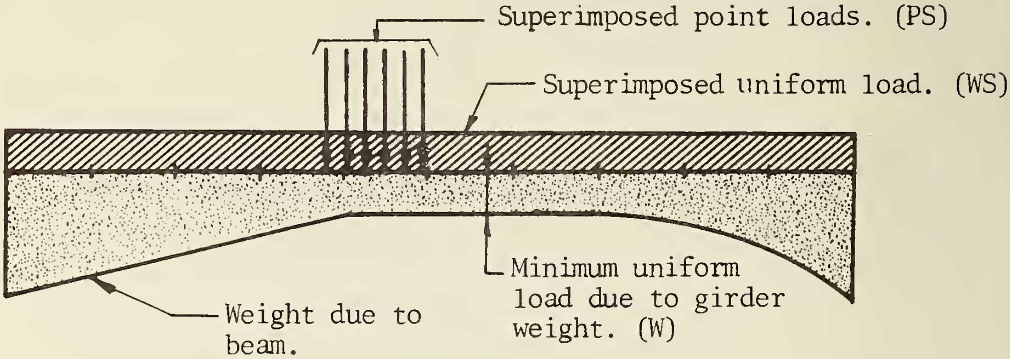
MNM = (GNSUM)(RSL)(IMPACT)(WFR)

MPV = (GPSUM)(IMPACT)(WFR)

MPR = (GPSUM)(IMPACT)(WFR)

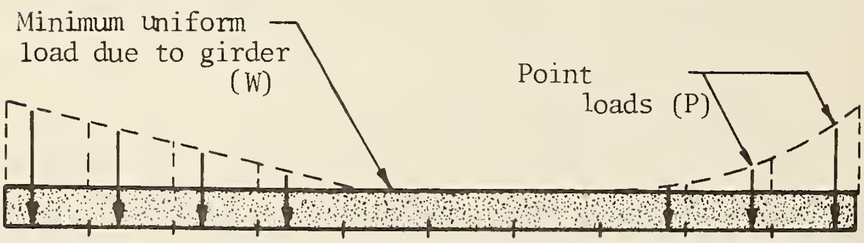
MNR = (GNSUM)(IMPACT)(WFR)

Static Load Moments, Shears and Reactions. Static load moments, shears and reactions are computed by loading the appropriate influence lines with the static loading conditions. The influence lines and their areas have already been computed and stored on disk; therefore, the following consists of the method used to break static loading down so that it may be applied to the influence lines.



ACTUAL STATIC LOADING ON A SPAN

FIGURE 63



SIMULATED STATIC LOADING DUE TO BEAM WEIGHT

FIGURE 64

The following generalized formulas solve for static superimposed load and static beam load moments, shears and reactions.

Where W = a uniform load over the whole span length
P = a point load at a point on the span
A = area under influence line for the span
C = coefficient on influence line corresponding to P load
L = length of span 1

Moment $= [\Sigma((A)(W)(L^2)) + \Sigma((P)(C)(L))]$

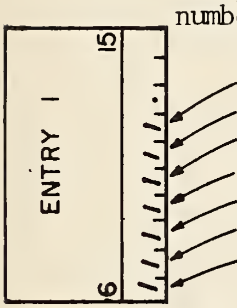
Shear $= [\Sigma((A)(W)(L)) + \Sigma((P)(C))]$

Reaction$= [\Sigma((A)(W)(L)) + \Sigma((P)(C))]$

3.2.3 Description of Input. Figure 65 shows the sign convention for all loading. The "Work Code" entry, "DC", is made only once.

a. Data Code 002 calls for entries as explained below.

Entry #1 asks for the type of output desired. By placing the number "1" in the proper space, you may request:



(1) Deflections (dead load and live load)
(2) Dead load report (moments, shears, reactions)
(3) Live load report (moments, shear, reactions)
(4) Maximum design values
(5) Deflection influence lines
(6) Deflection card input
(7) Live load composite run

Entry #2 calls for the wheel distribution factor.

Entry #3 calls for the percent of impact above one to be used. That is, if the internally calculated impact will be 1.3 and you desire it to be 1.15, this entry will equal 50.

Entries #4, #5 and #6 ask for the total weight of the trucks that are to be used for the review or rating of the structure, in tons. These trucks must be the same and be in the same sequence as those used in the deck routine.

b. Data Code 201 is the general data card. This card is always filled out.

Entry #1 calls for the uniform load on all spans that have been defined, kips per foot. Sometimes it will be better to leave this entry blank and use 202 cards.

Entry #2 calls for the unit weight of girder material, in kips per cubic foot.

Entry #3 calls for the modulus of elasticity of girder material, in kips per square inch. This entry is needed when deflections are wanted, except by the card input method. (See Entry #3 of the 401 card.)

c. Data Code 202 is the uniform load card. These loads override the uniform load specified in the 201 card. That is, any span that does not have the same load as the load in the 201 card may have any other load, including zero.

Entry #1 calls for the uniform load for span(s) defined by Entries #2 and #3, in kips per foot.

Entry #2 calls for the first span with the uniform load specified in Entry #1.

Entry #3 calls for the last span with the uniform load specified in Entry #1. This entry must be equal to or greater than Entry #2.

SIGN CONVENTION FOR STRUCTURE LOADING

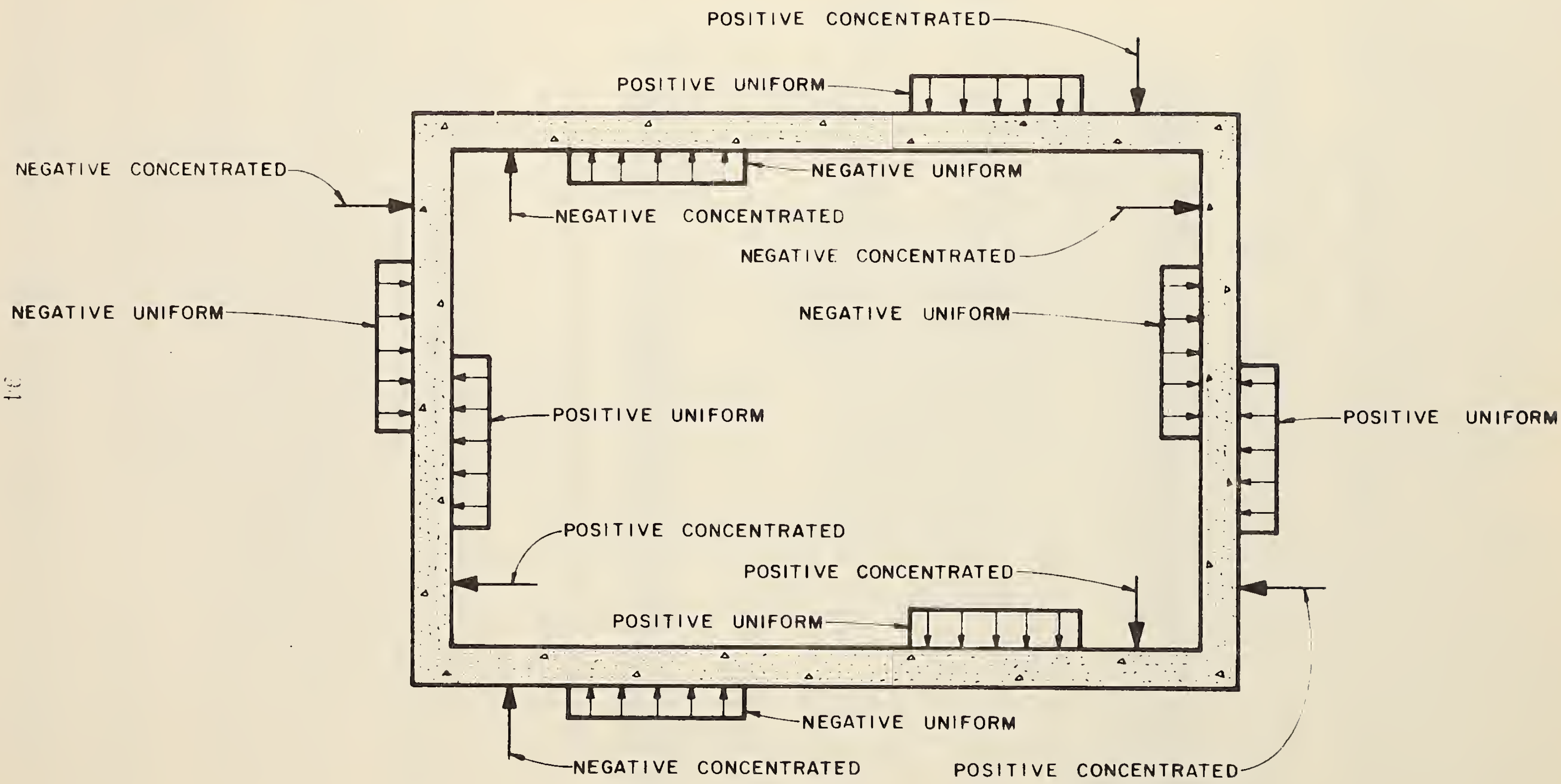


Figure 65

Entry #4 is uniform load for span(s) defined by Entries #5 and #6, in kips per foot.

Entry #5 is the first span with the uniform load specified in Entry #4.

Entry #6 calls for the last span with the uniform load specified in Entry #4. It must be equal to or greater than Entry #5.

d. Data Code 203 is the point load card. There may be a maximum of 36 of these cards (72 point loads).

Entry #1 calls for span number this point load is in.

Entry #2 calls for the distance from the left support of span this load is in to where the point load is acting, in feet.

Entry #3 calls for the magnitude of the point load, in kips.

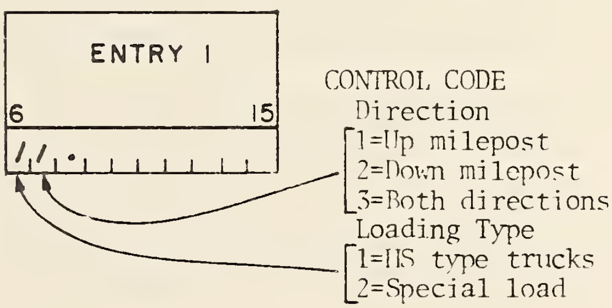
Entry #4 is the span number this point load is in.

Entry #5 calls for the distance from the left support of the span this load is in to where the point load is acting, in feet.

Entry #6 calls for the magnitude of the point load, in kips.

e. Data Code 301 thru 308 define the truck loads.

Entry #1 asks in which direction the reviewer desires the load to proceed across the structure. This entry also asks whether the live load is a standard HS truck or a special load vehicle.



Entry #2 is the weight of front wheel of truck, in kips.

Entry #3 calls for the distance from first wheel to second wheel, in feet.

Entry #4 is the weight of second wheel of truck, in kips.

Entry #5 calls for the distance from second wheel to third wheel, in feet. If Entry #1 is coded for HS20 loading, enter 14 feet.

Entry #6 is the weight of third wheel of truck, in kips.

f. Data Code 302 is a continuation of the truck load data. If Entry #1, 301 card is coded for an HS20 truck, enter 30 feet for Entry #1, 302 card.

Continue coding of wheel weights and spacings and increase data code by one for each additional card required for up to 24 truck wheels.

g. Data Code 309 is the lane load card. This card is filled out when live load moments, shears or deflections are wanted.

Entry #1 calls for the uniform lane load for live load, in kips per foot.

Entry #2 calls for the concentrated load for moment, in kips.

Entry #3 calls for the concentrated load for shear, in kips.

h. Data Code 401 is the span data card. This card is entered only when deflections are being solved for the use of card input.

Entry #1 calls for the length of span number one, which is always the reference span, in feet.

Entry #2 calls for the length of the span for which deflections are desired, in feet.

Entry #3 is the modulus of elasticity of girder material, in kips per square inch.

i. Data Code 402 is the real load moments card. This card is entered only when deflections are being solved for by the use of card input. The values entered are the real load moments at tenth points of the span for which the deflections are desired.

Entry #1 calls for real load moment at the left support, in kip-feet.

Entry #2 calls for real load moment at the 1/10 point on the span, in kip-feet.

Entry #3 calls for real load moment at the 2/10 point on the span, in kip-feet.

Entry #4 calls for real load moment at the 3/10 point on the span, in kip-feet.

Entry #5 calls for real load moment at the 4/10 point on the span, in kip-feet.

Entry #6 calls for real load moment at the 5/10 point on the span, in kip-feet.

j. Data Code 403 is a continuation of the 402 card.

Entry #1 calls for real load moment at the 6/10 point on the span-in kip-feet.

Entry #2 calls for real load moment at the 7/10 point on the span, in kip-feet.

Entry #3 calls for real load moment at the 8/10 point on the span, in kip-feet.

Entry #4 calls for real load moment at the 9/10 point on the span, in kip-feet.

Entry #5 calls for real load moment at the right support, in kip-feet.

k. Data Code 404 is the moments of inertia card. This card is entered only when deflections are being solved for by the use of card input. The entered values are the moments of inertia of the beam cross section at twentieth points of the span for which the deflections are wanted.

Entry #1 calls for the moment of inertia of the cross section at the left support, in $inches^4$.

Entry #2 calls for the moment of inertia of the cross section at the 1/20 point of the span, in $inches^4$.

Entry #3 calls for the moment of inertia of the cross section at the 2/20 point of the span, in $inches^4$.

Entry #4 calls for the moment of inertia of the cross section at the 3/20 point of the span, in $inches^4$.

Entry #5 calls for the moment of inertia of the cross section at the 4/20 point of the span, in $inches^4$.

Entry #6 calls for the moment of inertia of the cross section at the 5/20 point of the span, in $inches^4$.

l. Data Code 405 is a continuation of the 404 card.

Entry #1 calls for the moment of inertia of the cross section at the 6/20 point of the span, in $inches^4$.

Entry #2 calls for the moment of inertia of the cross section at the 7/20 point of the span, in $inches^4$.

Entry #3 calls for the moment of inertia of the cross section at the 8/20 point of the span, in $inches^4$.

Entry #4 calls for the moment of inertia of the cross section at the 9/20 point of the span, in $inches^4$.

Entry #5 calls for the moment of inertia of the cross section at the 10/20 point of the span, in $inches^4$.

Entry #6 calls for the moment of inertia of the cross section at the 11/20 point of the span, in $inches^4$.

m. Data Code 406 is a continuation of the 405 card.

Entry #1 is the moment of inertia of the cross section at the 12/20 point of the span, in $inches^4$.

Entry #2 is the moment of inertia of the cross section at the 13/20 point of the span, in $inches^4$.

Entry #3 is the moment of inertia of the cross section at the 14/20 point of the span, in $inches^4$.

Entry #4 is the moment of inertia of the cross section at the 15/20 point of the span, in $inches^4$.

Entry #5 is the moment of inertia of the cross section at the 16/20 point of the span, in $inches^4$.

Entry #6 is the moment of inertia of the cross section at the 17/20 point of the span, in $inches^4$.

n. Data Code 407 is a continuation of the 406 card.

Entry #1 is the moment of inertia of the cross section at the 18/20 point of the span, in $inches^4$.

Entry #2 is the moment of inertia of the cross section at the 19/20 point of the span, in $inches^4$.

Entry #3 is the moment of inertia of the cross section at the right support, in $inches^4$.

o. Data Code 408 is the left support moment influence line card. This card is entered only when deflections are being solved for by the use of card input. These values are the influence line coefficients at tenth points for the left support of the span for which the deflections are wanted.

Entry #1 calls for the influence line coefficient at the left support.

Entry #2 calls for the influence line coefficient at the 1/10 point of the span.

Entry #3 calls for the influence line coefficient at the 2/10 point of the span.

Entry #4 calls for the influence line coefficient at the 3/10 point of the span.

Entry #5 calls for the influence line coefficient at the 4/10 point of the span.

Entry #6 calls for the influence line coefficient at the 5/10 point of the span.

p. Data Code 409 is a continuation of the 408 card.

Entry #1 is the influence line coefficient at the 6/10 point of the span.

Entry #2 is the influence line coefficient at the 7/10 point of the span.

Entry #3 is the influence line coefficient at the 8/10 point of the span.

Entry #4 is the influence line coefficient at the 9/10 point of the span.

Entry #5 is the influence line coefficient at the right support.

q. Data Code 410 is the right support moment influence line card. This card is entered only when deflections are being solved for by the use of card input. These values are the influence line coefficients at tenth points for the right support of the span for which the deflections are wanted.

Entry #1 is the influence line coefficient at the left support.

Entry #2 is the influence line coefficient at the 1/10 point of the span.

Entry #3 is the influence line coefficient at the 2/10 point of the span.

Entry #4 is the influence line coefficient at the 3/10 point of the span.

Entry #5 is the influence line coefficient at the 4/10 point of the span.

Entry #6 is the influence line coefficient at the 5/10 point of the span.

r. Data Code 411 is a continuation of the 410 card.

Entry #1 is the influence line coefficient at the 6/10 point of the span.

Entry #2 is the influence line coefficient at the 7/10 point of the span.

Entry #3 is the influence line coefficient at the 8/10 point of the span.

Entry #4 is the influence line coefficient at the 9/10 point of the span.

Entry #5 is the influence line coefficient at the right support.

Pages 100 thru 105 are summaries of the required input data and supplement the aforementioned descriptions.

WORK CODE	D C			
DATA CODE	0 0 2 CONTROL CARD	2 0 1 GENERAL DATA	2 0 2 UNIFORM LOAD CARD (Modifies 201 Card Entry #1).	2 0 3 POINT LOAD CARD Maximum of 72 Point Loads (36 cards).
ENTRY 1	1111111 Deflections wanted Dead load Live load Max. Design values Deflect. infl. lines Deflection card input Live load composite m	Uniform load on all spans (This loading may be modified by 202 Card). Kips/Ft.	Uniform load on the following spans. Kips/Ft	Span number this load will be on.
ENTRY 2	Wheel fraction	Unit weight of the girder material. Kips/Cu. Ft.	First span with uniform load of Entry #1.	Distance from left support to point of application Feet
ENTRY 3	Percent of impact (above 1.) to be used.	Modulus of elasticity of girder material. Kips/Sq. In.	Last span with uniform load of Entry #1.	Magnitude of point load Kips
ENTRY 4	Total weight truck #1 Tons		Uniform load on the following spans. Kips/Ft.	Span number this load will be on.
ENTRY 5	Total weight truck #2 Tons		First span with uniform load of Entry #4.	Distance from left support to point of application Feet
ENTRY 6	Total weight truck #3 Tons		Last span with uniform load of Entry #4	Magnitude of point load Kips

	301	302	309	401
ENTRY 6	Truck wheel load #3 Kips	Truck wheel load #6 Kips		
ENTRY 5	Spacing between truck wheels #2 and #3. (When HS loading is indicated, enter minimum spacing). Feet	Spacing between truck wheels #5 and #6. Feet		
ENTRY 4	Truck wheel load #2 Kips	Truck wheel load #5 Kips		
ENTRY 3	Spacing between truck wheels #1 and #2 Feet	Spacing between truck wheels #4 and #5 Feet	Concentrated load for shear Kips	Modulus of elasticity of girder material. Kips/Sq. In.
ENTRY 2	Truck wheel load #1 Kips	Truck wheel load #4 Kips	Concentrated load for moment Kips	Length of span Feet
ENTRY 1	1 1 CONTROL CODE Direction Code 1=Up M.P. 2=Down M.P. 3=Up and down M.P. Loading Type 1=HS 2=Special load	Spacing between truck wheels #3 and #4. (When HS loading is indicated, enter maximum spacing between wheels #2 & #3) Feet	Uniform lane load Kips/Ft.	Length of span number one (Reference span)
DATA CODE	3 0 1 TRUCK LOAD DATA	3 0 2 TRUCK LOAD DATA (continued) Required for HS loading or more than 3 overload wheels.	3 0 9 LANE LOAD CARD	4 0 1 SPAN DATA FOR DEFLECTIONS (Card Input) Entry #1 of of 002 card must equal 100000.
WORK CODE				

	402	403	404	405
ENTRY 6	Moment at 5/10 point Kip-Feet		Moment of inertia at 5/20 point Inches^4	Moment of inertia at 11/20 point Inches^4
ENTRY 5	Moment at 4/10 point Kip-Feet	Moment at right support Kip-Feet	Moment of inertia at 4/20 point Inches^4	Moment of inertia at 10/20 point Inches^4
ENTRY 4	Moment at 3/10 point Kip-Feet	Moment at 9/10 point Kip-Feet	Moment of inertia at 3/20 point Inches^4	Moment of inertia at 9/20 point Inches^4
ENTRY 3	Moment at 2/10 point Kip-Feet	Moment at 8/10 point Kip-Feet	Moment of inertia at 2/20 point Inches^4	Moment of inertia at 8/20 point Inches^4
ENTRY 2	Moment at 1/10 point Kip-Feet	Moment at 7/10 point Kip-Feet	Moment of inertia at 1/20 point Inches^4	Moment of inertia at 7/20 point Inches^4
ENTRY 1	Moment at left support Kip-Feet	Moment at 6/10 point Kip-Feet	Moment of inertia at left support Inches^4	Moment of inertia at 6/20 point Inches^4
DATA CODE	4 0 2 REAL LOAD MOMENTS for Deflections (Card Input)	4 0 3 REAL LOAD MOMENTS (continued)	4 0 4 MOMENTS OF INERTIA for Deflections (Card Input)	4 0 5 MOMENTS OF INERTIA (continued)
WORK CODE				

ENTRY 6	Moment of inertia at 17/20 point Inches^4		Coefficient at 5/10 point	
ENTRY 5	Moment of inertia at 16/20 point Inches^4		Coefficient at 4/10 point	Coefficient at right support
ENTRY 4	Moment of inertia at 15/20 point Inches^4		Coefficient at 3/10 point	Coefficient at 9/10 point
ENTRY 3	Moment of inertia at 14/20 point Inches^4	Moment of inertia at right support Inches^4	Coefficient at 2/10 point	Coefficient at 8/10 point
ENTRY 2	Moment of inertia at 13/20 point Inches^4	Moment of inertia at 19/20 point Inches^4	Coefficient at 1/10 point	Coefficient at 7/10 point
ENTRY 1	Moment of inertia at 12/20 point Inches^4	Moment of inertia at 18/20 point Inches^4	Coefficient at left support	Coefficient at 6/10 point
DATA CODE	4 0 6 MOMENTS OF INERTIA	4 0 7 MOMENTS OF INERTIA	4 0 8 LEFT SUPPORT MOMENT INFLUENCE LINE	4 0 9 LEFT SUPPORT MOMENT INFLUENCE LINE
WORK CODE	(continued)	(continued)	for Deflections (Card Input)	(continued)

	Code 4.1.0	Code 4.1.1		
ENTRY 6	Coefficient at 5/10 point			
ENTRY 5	Coefficient at 4/10 point	Coefficient at right support		
ENTRY 4	Coefficient at 3/10 point	Coefficient at 9/10 point		
ENTRY 3	Coefficient at 2/10 point	Coefficient at 8/10 point		
ENTRY 2	Coefficient at 1/10 point	Coefficient at 7/10 point		
ENTRY 1	Coefficient at left support	Coefficient at 6/10 point		
DATA CODE	RIGHT SUPPORT MOMENT INFLUENCE LINE	RIGHT SUPPORT MOMENT INFLUENCE LINE		
WORK CODE	for Deflections (Card Input)	(continued)		

SUMMARY SHEET

FORM C-16
Rev 3/11/69

WYOMING STATE HIGHWAY DEPARTMENT
CHEYENNE WYOMING
BRIDGE DIVISION

//EXEC BRSYS00

DESIGN SYSTEM

SHEET NO. 1 OF 1
BY ______ DATE ______
CHECKED ______

Employee No. 69	Dept Code	Par D	Job Code 75	Work Code	Str No. 80

1 COMMENT CARD

1 0 0	STRUCTURAL LOADING

WORK CODE (1 2)	DATA CODE (3 5)	ENTRY 1 (6–15)	ENTRY 2 (25)	ENTRY 3 (35)	ENTRY 4 (45)	ENTRY 5 (55)	ENTRY 6 (65)	CONT (66)
0,1	0,0,2	Output control Request	Wheel traction	Percent of impact if desired	Total weight of truck #1	Total weight of truck #2	Total weight of truck #3	
	2,0,1	Uniform load on all spans (May be modified by 202 card)	Unit weight of girder material	Modulus of elasticity of girder material				
	2,0,2	Uniform load on following spans	First span with uniform load specified in Entry #1	Last span with uniform load specified in Entry #1	Uniform load on following spans	First span with uniform load specified in Entry #1	Last span with uniform load specified in Entry #1	
	2,0,3	Span number in which the point load is located	Dist. from left support to load specified in Entry #1	Magnitude of load specified in Entry #1	Span number in which the point load is located	Dist. from left support to load specified in Entry #4	Magnitude of load specified in Entry #1	
	3 0 1	Direction code and Loading type Request	Truck wheel load #1	Spacing between truck wheels #1 and #2	Truck wheel load #2	Spacing between truck wheels #2 and #3	Truck wheel load #3	
	3 0 2	Spacing between truck wheels #3 and #4	Truck wheel load #4	Spacing between truck wheels #4 and #5	Truck wheel load #5	Spacing between truck wheels #5 and #6	Truck wheel load #6	
	3 0 3	Uniform lane load	Concentrated load for moment	Concentrated load for shear				
	4 0 1	Length of Span number one (Reference Span)	Length of Span	Modulus of Elasticity				
	4 0 2	Moment at Left Support	Moment at .1 Point	Moment at .2 Point	Moment at .3 Point	Moment at .4 Point	Moment at .5 Point	
	4,0,3	Moment at .6 Point	Moment at .7 Point	Moment at .8 Point	Moment at .9 Point	Moment at Right Support		
	4,0,4	Moment of Inertia at Left Support	Moment of Inertia at .05 Point	Moment of Inertia at .10 Point	Moment of Inertia at .15 Point	Moment of Inertia at .20 Point	Moment of Inertia at .25 Point	
	4,0,5	Moment of Inertia at .30 Point	Moment of Inertia at .35 Point	Moment of Inertia at .40 Point	Moment of Inertia at .45 Point	Moment of Inertia at .50 Point	Moment of Inertia at .55 Point	
	4,0,6	Moment of Inertia at .60 Point	Moment of Inertia at .65 Point	Moment of Inertia at .70 Point	Moment of Inertia at .75 Point	Moment of Inertia at .80 Point	Moment of Inertia at .85 Point	
	4,0,7	Moment of Inertia at .90 Point	Moment of Inertia at .95 Point	Moment of Inertia at Right Support				
	4 0 8	Coefficient at Left Support	Coefficient at .1 Point	Coefficient at .2 Point	Coefficient at .3 Point	Coefficient at .4 Point	Coefficient at .5 Point	
	4 0 9	Coefficient at .6 Point	Coefficient at .7 Point	Coefficient at .8 Point	Coefficient at .9 Point	Coefficient at Right Support		
	4,1,0	Coefficient at Left Support	Coefficient at .1 Point	Coefficient at .2 Point	Coefficient at .3 Point	Coefficient at .4 Point	Coefficient at .5 Point	
	4,1,1	Coefficient at .6 Point	Coefficient at .7 Point	Coefficient at .8 Point	Coefficient at .9 Point	Coefficient at Right Support		

TRAILER CARD

9 9 9 (1–3)	

NOTE: A trailer card must follow the last structure card containing data

Figure 66

3.2.4 Description of Output. All output has been designed to be as self-documenting as possible. The output consists of a listing of all input entered, and blocks of output data corresponding to the various types of reports requested by the user.

All output reports are in a column and row format. All columns and rows on a report are labeled as to the type of values contained in the column or row. Values are listed for requested types of loading for tenth points on all spans with the exception of reactions, which are listed at span supports only.

Output for design values consists of the combination of the respective static and live load values to obtain maximum values to be used in a design.

Output for static load deflections is printed out both in decimals of an inch and fractions of an inch to sixteenths.

3.3 Section Design, Review and Rating

3.3.1 General Information. This component will design, review and rate steel, concrete, timber and composite sections.

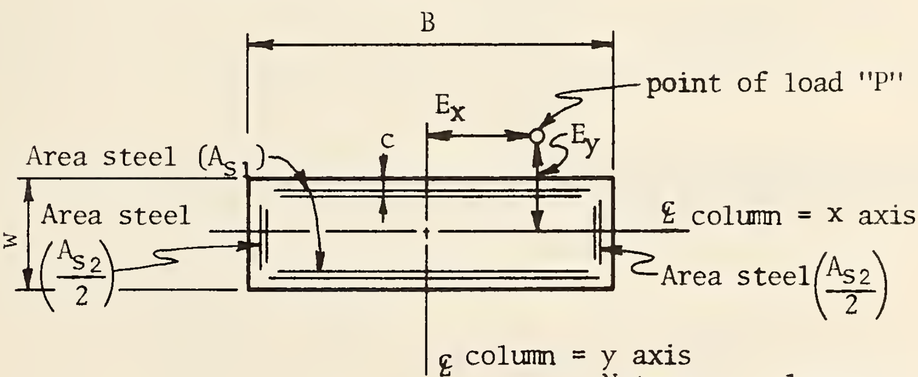
When designing a structure, only data having to do with general characteristics are entered. In concrete design, clearances to steel, breaking strength of concrete, yield strength of reinforcing and percentages need only be entered. When designing steel structures, only steel properties and percentages need be entered.

A set of data must be coded for every section to be investigated. For this reason the capability of choosing design points is included.

If a design point is to be investigated for only one given action, such as shear, then only those applicable stresses need be input in the review and rating. Conversely, if a given action in any one section is not desired, the allowable stress parameters may be set equal to zero.

3.3.2 Mathematical Equations and Derivations.

a. Rectangular Column



Note: c = clearance to ℄ steel

TYPICAL SECTION

This stress checking method is a new approach to a difficult problem. The basic idea is to reduce the check to two separate checks. The first check is made for the load that causes the greatest e/t ratio, and then adding to the stresses found, the ones caused by the least e/t ratio.

The problem, then, is to first calculate the e/t ratios

$$e_x = E_x / B$$

$$e_y = E_y / w$$

Checking to see if the column is a cracked section,

$$e_x + e_y \geq .273$$

and if

$$E_y \leqq w / 6$$

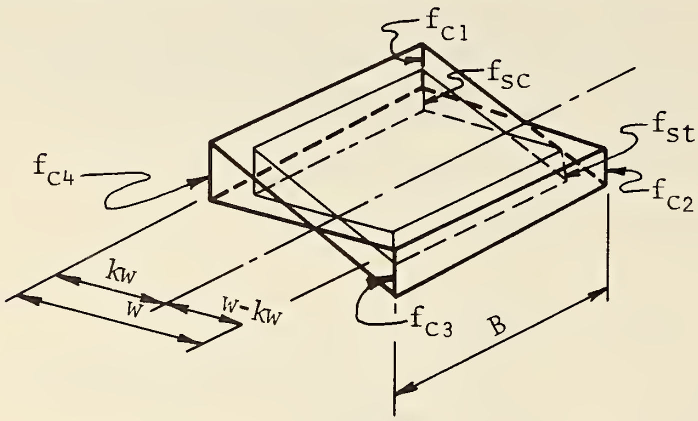
$$E_x \leqq B / 6$$

If a cracked section is indicated and E_y is less than $w/6$, we reorient the section by setting

$$E_x = E_y \qquad B = w$$

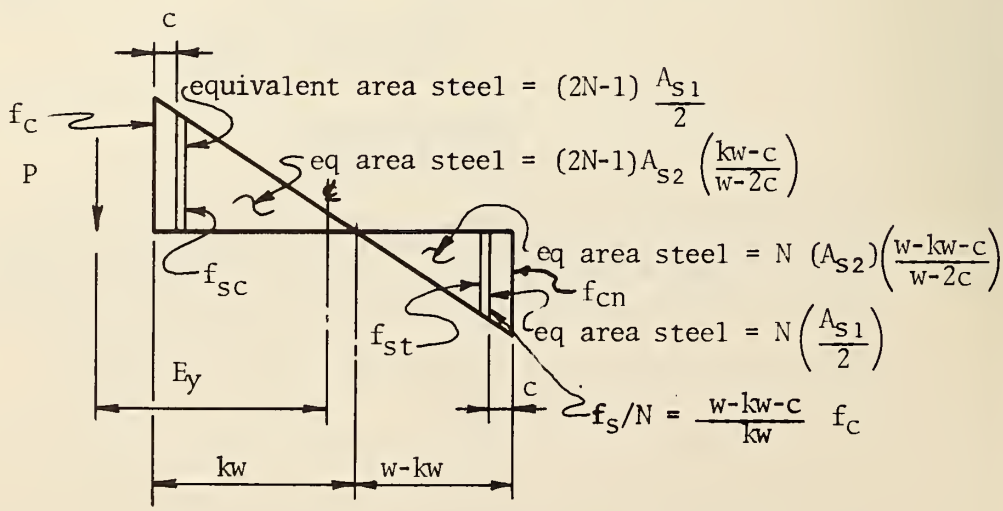
$$E_y = E_x \qquad w = B$$

If the section is cracked and E_y is equal to or greater than $w/6$, we find the stresses in each corner from the moment caused by E_y.



$$f_{c1} = f_{c4}$$
$$f_{c2} = f_{c3}$$

CHECK NO. 1 STRESS PATTERN
(Initial stresses from E_y)



CROSS SECTION OF STRESS PATTERN

Writing summation of moments about "P" (ΣM_p):

$$\Sigma M_p = 0 = -f_c\left(\frac{kw}{2}\right)B\left(E_y-\frac{w}{2}+\frac{kw}{3}\right)-f_{sc}(2N-1)\ \frac{A_{s1}}{2}\ \left(E_y-\frac{w}{2}+c\right)$$

$$- \frac{f_{sc}}{2}(2N-1)A_{s2}\left(\frac{kw-c}{w-2c}\right)\left(E_y - \frac{w}{2} + c + \frac{kw-c}{3}\right)$$

$$+f_{st}(N)\frac{A_{s1}}{2}(E_y+\frac{w}{2}-c) + \frac{f_{st}}{2}(N)A_{s2}\left(\frac{w-kw-c}{w-2c}\right)\left(E_y+\frac{w}{2}-c-\frac{w-kw-c}{3}\right)$$

and

$$f_{sc} = f_c\left(\frac{kw-c}{kw}\right)$$

$$f_{st} = f_c\left(\frac{w-kw-c}{kw}\right)$$

set the identities

$$X_1 = E_y + \frac{w}{2} - c$$

$$X_2 = E_y - \frac{w}{2}$$

$$X_3 = E_y - \frac{w}{2} + c$$

therefore,

$$\Sigma M_p = 0 = -f_c\left(\frac{kw}{2}\right)B\left(X_2+\frac{kw}{3}\right) - f_c\left(\frac{kw-c}{kw}\right)\frac{2N-1}{2}\left[A_{s1}(X_3) + A_{s2}\left(\frac{kw-c}{w-2c}\right)\left(X_3 + \frac{kw-c}{3}\right)\right] + \left(\frac{w-kw-c}{kw}\right)f_c\left(\frac{N}{2}\right)\left[A_{s1}(X_1) + A_{s2}\left(\frac{w-kw-c}{w-2c}\right)\left(X_1-\frac{w-kw-c}{3}\right)\right]$$

and dividing both sides by f_c,

$$\Sigma M_p = 0 = \frac{-B(kw)}{2}\left(X_2+\frac{kw}{3}\right)-\frac{(2N-1)}{2}\left(\frac{kw-c}{kw}\right)\left[A_{s1}(X_3)+A_{s2}\left(\frac{kw-c}{w-2c}\right)\left(X_3+\frac{kw-c}{3}\right)\right] + \frac{N}{2}\left(\frac{w-kw-c}{kw}\right)\left[A_{s1}(X_1)+A_{s2}\left(\frac{w-kw-c}{w-2c}\right)\left(X_1-\frac{w-kw-c}{3}\right)\right] \quad \text{(Equation 1)}$$

Solving for kw gives the distance to the neutral axis and consequently the new section for the additional moment (E_x).

To find the stress in the concrete from the applied load, we write an equation for summation of verticals ($\Sigma V=0$).

$$\Sigma V = 0 = P+f_{st}(A_{s1})\frac{N}{2} + f_{st}(A_{s2})\frac{N}{2}\left(\frac{w-kw-c}{w-2c}\right)-f_{sc}(A_{s1})\left(\frac{2N-1}{2}\right) - f_{sc}\left(\frac{2N-1}{2}\right)\left(\frac{kw-c}{w-2c}\right)A_{s2} - f_c(kw)\frac{B}{2}$$

substituting for f_{sc} and f_{st},

$$V = 0 = P + f_c\left(\frac{w-kw-c}{kw}\right)\left(\frac{N}{2}\right)\left[A_{s1} + A_{s2}\left(\frac{w-kw-c}{w-2c}\right)\right] - f_c(kw)\,\frac{B}{2} - f_c\left(\frac{kw-c}{kw}\right)$$

$$\left(\frac{2N-1}{2}\right)\left[A_{s1} + A_{s2}\left(\frac{kw-c}{w-2c}\right)\right]$$

Solving for f_c

$$f_c = P/\left[\frac{N}{2}\left[\frac{w-kw-c}{kw}\right]\left[A_{s1} + A_{s2}\left[\frac{w-kw-c}{w-2c}\right]\right] - B\left[\frac{kw}{2}\right] - \frac{2N-1}{2}\left[\frac{kw-c}{kw}\right]\right.$$

$$\left.\left[A_{s1} + A_{s2}\left[\frac{kw-c}{w-2c}\right]\right]\right]$$

Solving for tension in steel (f_{st})

$$f_{st} = \left(\frac{w-kw-c}{kw}\right) f_c(N)$$

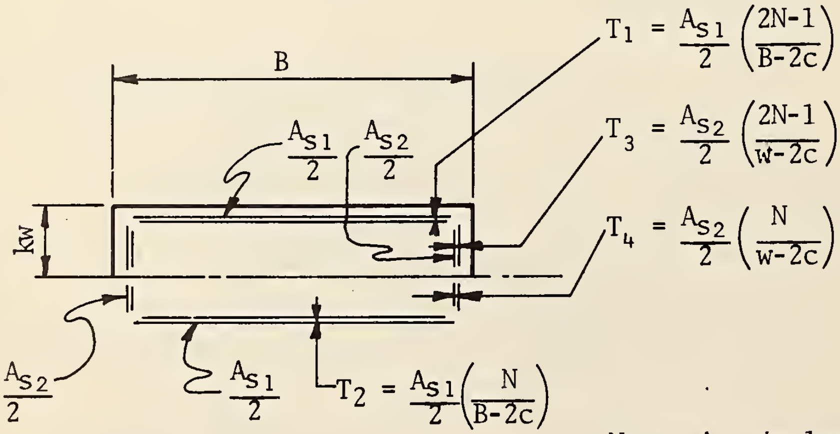
Solving for compression in steel (f_{sc})

$$f_{sc} = f_c\left(\frac{kw-c}{kw}\right)(2N-1)$$

Solving for fictional stress in concrete (tension)(f_{c2} & f_{c3})

$$f_{cn} = -f_c\left(\frac{w-kw}{kw}\right)$$

By assuming the concrete section is now kw wide and B long and including the equivalent concrete from the reinforcing steel, we find the stresses due to the influence of the moment caused by the X-eccentricity (E_x).



Note: A_{s2} includes T_3 & T_4

NEW EFFECTIVE SECTION

The stresses are

$$f_y = \pm\frac{P(E_x)\left(\frac{B}{2}\right)}{I_y}$$

$$I_y = \frac{1}{12}(kw)B^3 + \frac{1}{12}T_1(B-2c)^3 + \frac{1}{12}T_2(B-2c)^3 + 2(T_3)(kw-c)\left(\frac{B-2c}{2}\right)^2$$

$$+ 2(T_4)(w-kw-c)\frac{(B-2c)^2}{2}$$

The final stresses are found by summation

$$f_{c1} = f_c + f_y$$

$$f_{c2} = f_{cn} - f_y$$

$$f_{c3} = f_{cn} + f_y$$

$$f_{c4} = f_c - f_y$$

The new distances to the neutral axis are found from the concrete stresses:

$$kw_1 = w\left(\frac{f_{c1}}{f_{c1}-f_{c2}}\right)$$

$$kw_2 = w\left(\frac{f_{c4}}{f_{c4}-f_{c3}}\right)$$

The final stresses in the steel are

$$f_{st} = f_{c4}\left(\frac{w-kw_2-c}{kw_2}\right)N$$

$$f_{sc} = f_{c1}\left(\frac{kw_1-c}{kw_1}\right)(2N-1)$$

When the section is not of a cracked type, then the stresses are found by

$$f_c = \frac{P}{A} \pm \frac{P(E_x)x}{I_y} \pm \frac{P(E_y)y}{I_x}$$

$$f_{sn} = \left[f_{c2} + \frac{(f_{c1}-f_{c2})}{w}(w-c)\right] \quad (2n-1)$$

$$f_{st} = \left[f_{c4} + \frac{(f_{c3}-f_{c4})}{w}(w-c)\right] \quad (N)$$

Where I_y is as above with kw equal to w and

$$I_x = \frac{1}{12}B(w)^3 + A_{s1}\left[\frac{(w-2c)}{2}\right]^2 + \frac{1}{6}T_3(w-2c)^3$$

The expansion of Equation 1, page 109, is

$$kw^3\left[-\frac{B}{3} - \frac{A_{s2}(N-1)}{3(w-2c)}\right] + kw^2\left[-B(X_2) - \frac{A_{s2}(N-1)X_2}{(w-2c)}\right] + kw\left[\frac{A_{s2}}{(w-2c)}\right.$$

$$\Big[\left[(2N-1)c(2X_3-c)+N(w-c)((w-c)-2X_1)\right] - A_{s1}((2N-1)X_3+N(X_1))\Big]$$

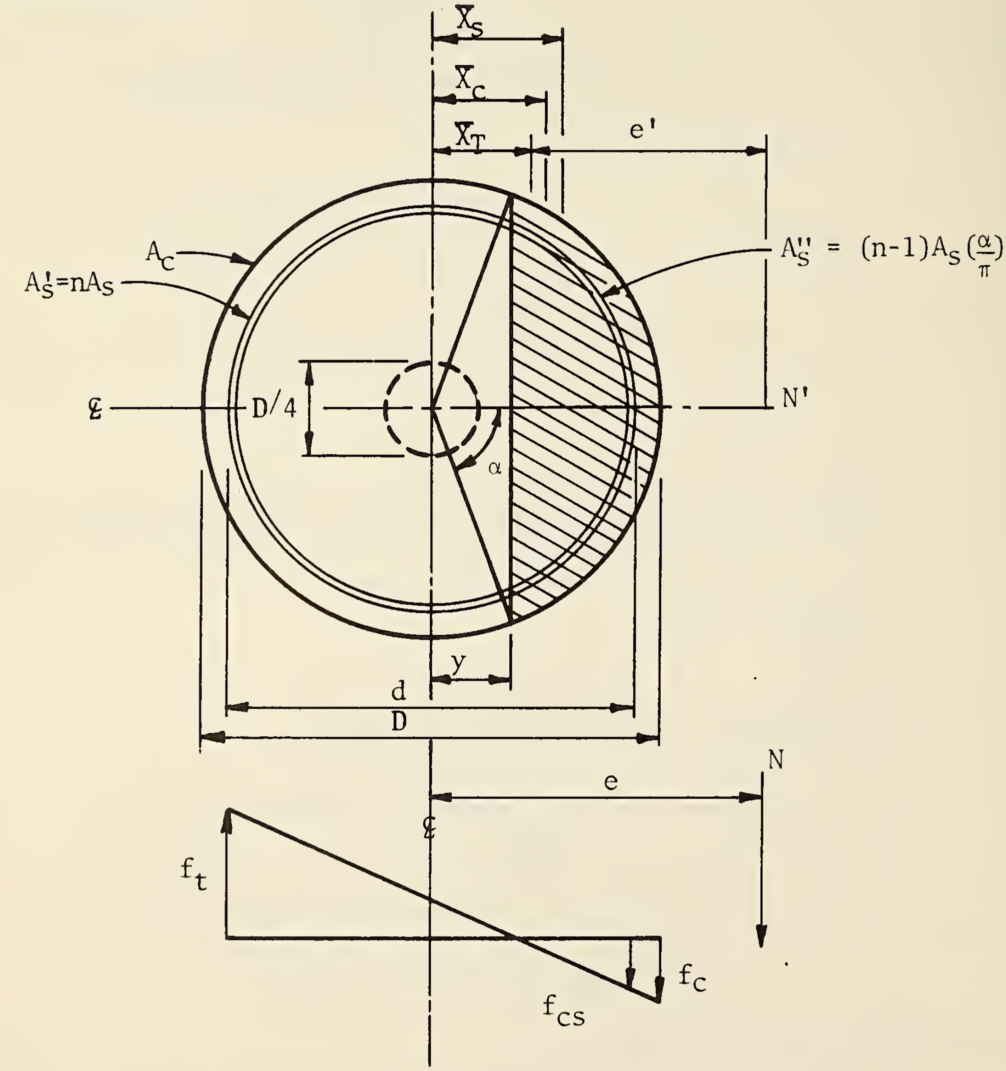
$$+\Big[A_{s1}(c(2N-1)X_3+(w-c)N(X_1)) - \frac{A_{s2}(2N-1)c^2}{(w-2c)}\left(X_3-\frac{c}{3}\right)+\frac{A_{s2}(N)}{(w-2c)}$$

$$(w-c)^2\left[X_1-\frac{w-c}{3}\right]\Big] = 0$$

b. Circular Column

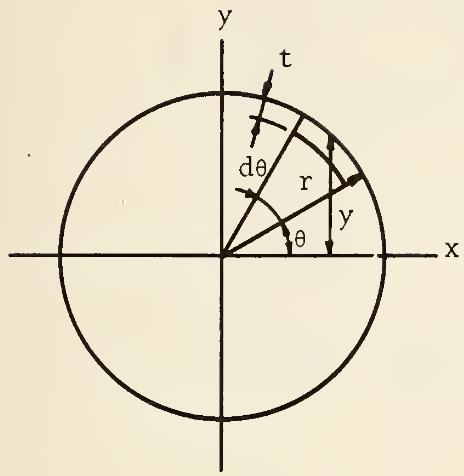
Basic Sketch

Cracked Section



GIVEN: N, e, n, A_s, D, d
FIND: Final Stresses f_c, f_s, f_s'
RESTRICTIONS: Eccentricity Ratio Greater Than .5

Steel Ring



$$I = \int y^2 dA$$

$$y = r \sin \theta$$

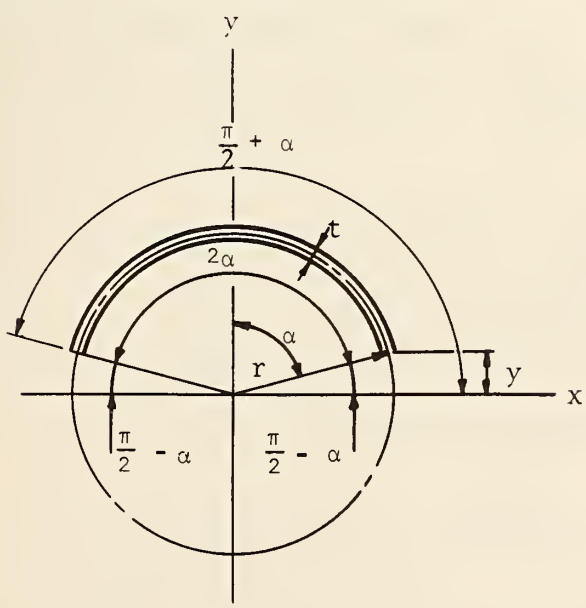
$$dA = r d\theta \ \ t$$

$$I_{xx} = t\int r^2 \sin^2\theta dA = t\int r^2 \sin^2\theta r d\theta$$

$$= t\int r^3 \sin^2\theta d\theta$$

$$I_{xx} = tr^3\left[\frac{\theta}{2} - \frac{\sin 2\theta}{4}\right]$$

Any Arc



$$I_{xx} = tr^3\left[\frac{\theta}{2} - \frac{\sin 2\theta}{4}\right]_{\frac{\pi}{2}-\alpha}^{\frac{\pi}{2}+\alpha}$$

$$tr^3\left[\frac{\frac{\pi}{2}+\alpha}{2} - \frac{\sin(\pi+2\alpha)}{4}\right]$$

$$-tr^3\left[\frac{\frac{\pi}{2}-\alpha}{2} - \frac{\sin(\pi-2\alpha)}{4}\right]$$

$$I_{xx} = \frac{tr^3}{2}(2\alpha+\sin 2\alpha)$$

Centroid of Arc, $\bar{y}$

$$L = 2r\alpha$$

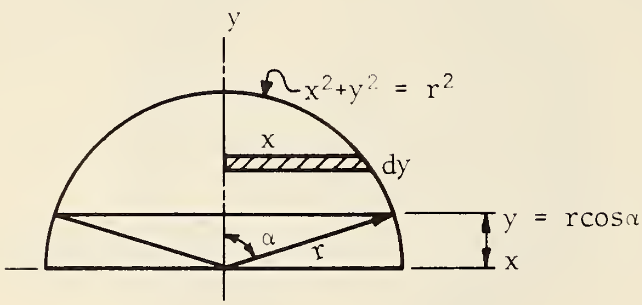
$$L\bar{y} = \int y\,dA = \int r \sin\theta \; r\,d\theta = r^2\int \sin\theta\, d\theta$$

$$= r^2\Big[-\cos\theta\Big]_{\frac{\pi}{2}-\alpha}^{\frac{\pi}{2}+\alpha} = r^2\left[-\cos\left(\frac{\pi}{2}+\alpha\right) + \cos\left(\frac{\pi}{2}-\alpha\right)\right]$$

$$L\bar{y} = r^2[\sin\alpha+\sin\alpha] = 2r^2\sin\alpha$$

$$\bar{y} = \frac{2r^2\sin\alpha}{2r\alpha} \qquad \bar{y} = \frac{r\sin\alpha}{\alpha}$$

Concrete Segment



$$A = 2\int dA = 2\int x\,dy = 2\int_{r\cos\alpha}^{r} \sqrt{r^2-y^2}\; dy$$

$$= \left[y\sqrt{r^2-y^2} + r^2\sin^{-1}\left(\frac{y}{r}\right)\right]_{r\cos\alpha}^{r}$$

$$= \left[r^2\sin^{-1}1\right] - \left[r\cos\alpha\sqrt{r^2-r^2\cos^2\alpha} + r^2\sin^{-1}(\cos\alpha)\right]$$

$$= \left[\frac{r^2\pi}{2}\right] - \left[r\cos\alpha\sin\alpha + r^2\left(\frac{\pi-2\alpha}{2}\right)\right]$$

$$= \frac{r^2\pi}{2} - \frac{r^2\sin 2\alpha}{2} - \frac{r^2\pi}{2} + \frac{2r^2\alpha}{2}$$

$$= \frac{r^2}{2}\left[\pi-\sin 2\alpha-\pi+2\alpha\right]$$

$$A_c = \frac{r^2}{2}\left[2\alpha-\sin 2\alpha\right]$$

Centroid of Segment

$$A_c \bar{X}_c = 2\int_{r\cos\alpha}^{r} y\sqrt{r^2-y^2}\,dy = 2\left[-\frac{(r^2-y^2)^{3/2}}{3}\right]_{r\cos\alpha}^{r}$$

$$= 2\left[\frac{(r^2(1-\cos^2\alpha))^{3/2}}{3}\right] = \frac{2[r^2\sin^2\alpha]^{3/2}}{3}$$

$$= \frac{2r^3\sin^3\alpha}{3}$$

$$\bar{X}_c = \frac{2r^3\sin^3\alpha}{3A_c} = \frac{2r^3\sin^3\alpha}{\frac{3r^2}{2}(2\alpha-\sin2\alpha)}$$

$$\bar{X}_c = \frac{4r\sin^3\alpha}{3(2\alpha-\sin2\alpha)}$$

Concrete Segment, Moment of Inertia

$$I_{xx} = 2\int_{r\cos\alpha}^{r} y^2\sqrt{r^2-y^2}\,dy = 2\left[\frac{-y(r^2-y^2)^{3/2}}{4} + \frac{r^2y(r^2-y^2)^{1/2}}{8} + \frac{r^4}{8}\sin^{-1}\frac{y}{r}\right]_{r\cos\alpha}^{r}$$

$$= 2\left(\frac{r^4\pi}{16} + \left[\frac{r^4\sin^3\alpha\cos\alpha}{4} - \frac{r^4\sin\alpha\cos\alpha}{8} - \frac{r^4\pi}{16} + \frac{r^4\alpha}{8}\right]\right)$$

$$= 2\left[\frac{r^4\pi}{16} + \frac{r^4\sin^3\alpha\cos\alpha}{4} - \frac{r^4\sin\alpha\cos\alpha}{8} - \frac{r^4\pi}{16} + \frac{r^4\alpha}{8}\right]$$

$$= \frac{r^4\alpha}{4} + \frac{2r^4\sin^3\alpha\cos\alpha}{4} - \frac{r^4\sin\alpha\cos\alpha}{4}$$

$$= \frac{r^4}{4}\left[\alpha+2\sin^3\alpha\cos\alpha-\frac{\sin2\alpha}{2}\right]$$

$$= \frac{r^4}{8}[2\alpha-\sin2\alpha+4\sin^3\alpha\cos\alpha]$$

$$= \frac{r^4}{8}(2\alpha-\sin2\alpha) + \frac{r^4}{8}(4\sin^3\alpha\cos\alpha)$$

$$= \frac{A_c r^2}{4} + \frac{2r^4\sin^3\alpha\cos\alpha}{4} = \frac{A_c r^2}{4}\left[\frac{A_c}{A_c} + \frac{2r^2\sin^3\alpha\cos\alpha}{A_c}\right]$$

$$= \frac{A_c r^2}{4}\left[1 + \frac{2r^2 \sin^3\alpha\cos\alpha}{\frac{r^2}{2}(2\alpha - \sin 2\alpha)}\right] = \frac{A_c r^2}{4}\left(1 + \frac{4\sin^3\alpha\cos\alpha}{2\alpha - \sin 2\alpha}\right)$$

$$I_{xx} = \frac{A_c r^2}{4}\left(1 + \frac{2\sin^3\alpha\cos\alpha}{\alpha - \sin\alpha\cos\alpha}\right)$$

Moment of Inertia of Steel Ring, $t = 1$

$$I_{xx} = \frac{r^3}{2}\left(2\pi + \frac{\sin 4\pi}{2}\right) = \pi r^3 = \frac{2\pi r r^2}{2}$$

$$d = 2r \; ; \; 2\pi r = nA_s \; ; \; I_{xx} = \frac{nA_s d^2}{8}$$

Moment of Inertia of Arc for Steel Ring, $t = 1$

$$I_{xx} = \frac{r^3}{2}[2\alpha + \sin 2\alpha] \; ; \; L = (2r)\alpha = \frac{\alpha}{\pi}(n-1)A_s$$

$$= \frac{(2r)\alpha}{2r\alpha}\,\frac{r^3}{2}[2\alpha + \sin 2\alpha]$$

Replace Length of Arc with Area of Steel

$$I_{xx} = \frac{(n-1)(A_s)\alpha}{(\pi)\,(2rd)}\,\frac{r^3}{2}[2\alpha + \sin 2\alpha]$$

$$I_{xx} = \frac{(n-1)A_s\,r^2}{4\pi}[2\alpha + \sin 2\alpha]$$

$$I_{xx} = \frac{(n-1)A_s d^2}{16\pi}[2\alpha + \sin 2\alpha]$$

$$(n-1)A_s = \frac{A_s''\pi}{\alpha}$$

$$I_{xx} = \frac{A_s''\pi}{\alpha}\,\frac{d^2}{16\pi}(2\alpha + \sin 2\alpha) = \frac{d^2 A_s''}{16\alpha}(2\alpha + \sin 2\alpha)$$

FUNCTION	DERIVATIVE
$A'_S = nA_S$	$\frac{dA'_S}{dy} = 0$ (none)
$A''_S = \left[\frac{(n-1)A_S}{\pi}\right]\alpha$	$\frac{dA''_S}{dy} = \left[\frac{(n-1)A_S}{\pi}\right]\frac{d\alpha}{dy}$
$A_C = \frac{D^2}{8}(2\alpha - \sin 2\alpha)$	$\frac{dA_C}{dy} = \frac{D^2}{4}(1-\cos 2\alpha)\frac{d\alpha}{dy}$
$A_T = A'_S + A''_S + A_C$	$\frac{dA_T}{dy} = 0 + \frac{dA''_S}{dy} + \frac{dA_C}{dy}$
$\alpha = \tan^{-1}\left[\frac{\sqrt{D^2-4y^2}}{2y}\right]$	$\frac{d\alpha}{dy} = \frac{-2}{\sqrt{D^2-4y^2}} = \frac{-2}{D\sin\alpha}$
$\overline{X}_S = \frac{d\sin\alpha}{2\alpha}$	$\frac{d\overline{X}_S}{dy} = \frac{d(\alpha\cos\alpha - \sin\alpha)}{2\alpha^2}\frac{d\alpha}{dy}$
$\overline{X}_C = \frac{2D\sin^3\alpha}{3(2\alpha - \sin 2\alpha)}$	$\frac{d\overline{X}_C}{dy} = \left[\frac{(6D)(2\alpha-\sin 2\alpha)(\sin^2\alpha\cos\alpha) - (4D)(\sin^3\alpha)(1-\cos 2\alpha)}{3(2\alpha - \sin 2\alpha)^2}\right]\frac{d\alpha}{dy}$
$\overline{X}_T = \frac{A''_S\overline{X}_S + A_C\overline{X}_C}{A_T}$	$\frac{d\overline{X}_T}{dy} = \left[\frac{A_T\left(\overline{X}_S\frac{dA''_S}{dy} + A''_S\frac{d\overline{X}_S}{dy} + \overline{X}_C\frac{dA_C}{dy} + A_C\frac{d\overline{X}_C}{dy}\right) - \left(A''_S\overline{X}_S + A_C\overline{X}_C\right)\frac{dA_T}{dy}}{A_T^2}\right]$
$C_S = \frac{d}{2} + \overline{X}_T$	$\frac{dC_S}{dy} = \frac{d\overline{X}_T}{dy}$
$C_C = \frac{D}{2} - \overline{X}_T$	$\frac{de_C}{dy} = \frac{-d\overline{X}_T}{dy}$
$C'_{CS} = \frac{d}{2} - \overline{X}_T$	(none required)
$e' = e - \overline{X}_T$	$\frac{de'}{dy} = \frac{-d\overline{X}_T}{dy}$
(continued)	(continued)

FUNCTION	DERIVATIVE
$f_t = \frac{P}{A_T} - \frac{Pe'C_s}{I_T}$	$\frac{df_t}{dy} = \frac{-P}{A_T^2}\frac{dA_T}{dy} - \left(\frac{P}{I_T^2}\right)\left[I_T\left(e'\frac{dC_s}{dy} + C_s\frac{de'}{dy}\right) - e'C_s\frac{dI_T}{dy}\right]$
$f_c = \frac{P}{A_T} + \frac{Pe'C_c}{I_T}$	$\frac{df_c}{dy} = \frac{-P}{A_T^2}\frac{dA_T}{dy} + \left(\frac{P}{I_T^2}\right)\left[I_T\left(e'\frac{dC_c}{dy} + C_c\frac{de'}{dy}\right) - e'C_c\frac{dI_T}{dy}\right]$
$f_{cs} = \frac{P}{A_T} + \frac{Pe'C_{cs}}{I_T}$	(none required)
* $f(y) = y - \frac{D}{2} + \left(\frac{d+D}{2}\right)\left(\frac{f_c}{f_c-f_t}\right) = 0$	$\frac{df(y)}{dy} = 1 + \left(\frac{d+D}{2}\right)\left[\left(f_c\frac{df_t}{dy} - f_t\frac{df_c}{dy}\right)\Big/(f_c-f_t)^2\right] = 0$
** $Y_{i+1} = Y_i - \frac{f(y)}{f'(y)}$	(none required)
$I_T = \left(\frac{A_cD^2}{16}\right)\left(1 + \frac{2\sin^3\alpha\cos\alpha}{\alpha-\sin\alpha\cos\alpha}\right)$ $+ A_c(\bar{X}_T^2 - 2\bar{X}_T\bar{X}_c)$ $+ A_s'\frac{d^2}{8} + A_s'\bar{X}_T^2$ $+\left(\frac{A_s''d^2}{16\alpha}\right)(2\alpha+\sin 2\alpha)$ $+ A_s''(\bar{X}_T^2 - 2\bar{X}_T\bar{X}_s)$	$\frac{dI_T}{dy} = \left(\frac{A_cD^2}{16}\right)\left[\frac{(\alpha-\sin\alpha\cos\alpha)(6\sin^2\alpha-8\sin^4\alpha)-(4\sin^5\alpha\cos\alpha)}{(\alpha-\sin\alpha\cos\alpha)^2}\right]\frac{d\alpha}{dy}$ $+\left[1 + \frac{2\sin^3\alpha\cos\alpha}{\alpha-\sin\alpha\cos\alpha}\right]\frac{D^2}{16}\frac{dA_c}{dy} + 2A_c\left[(\bar{X}_T-\bar{X}_c)\frac{d\bar{X}_T}{dy} - \bar{X}_T\frac{d\bar{X}_c}{dy}\right]$ $+ (\bar{X}_T^2 - 2\bar{X}_T\bar{X}_c)\frac{dA_c}{dy} + 2(\bar{X}_TA_s')\frac{d\bar{X}_T}{dy}$ $+ \frac{d^2A_s''}{8\alpha}(1+\cos 2\alpha)\frac{d\alpha}{dy} + \frac{d^2(2\alpha+\sin 2\alpha)}{16\alpha^2}\left(\frac{\alpha dA_s''}{dy} - A_s''\frac{d\alpha}{dy}\right)$ $+ \frac{dA_s''}{dy}(\bar{X}_T^2 - 2\bar{X}_T\bar{X}_s) + 2A_s''\left[(\bar{X}_T-\bar{X}_s)\frac{d\bar{X}_T}{dy} - \bar{X}_T\frac{d\bar{X}_s}{dy}\right]$

* Main Function
** Newton's Method of Root Improvement

c. Reinforced Concrete (Excluding Columns) Design. The equations are found in "Reinforced Concrete Design Handbook, Working Stress Method", Third Edition, published by ACI, example 18, on page 31.

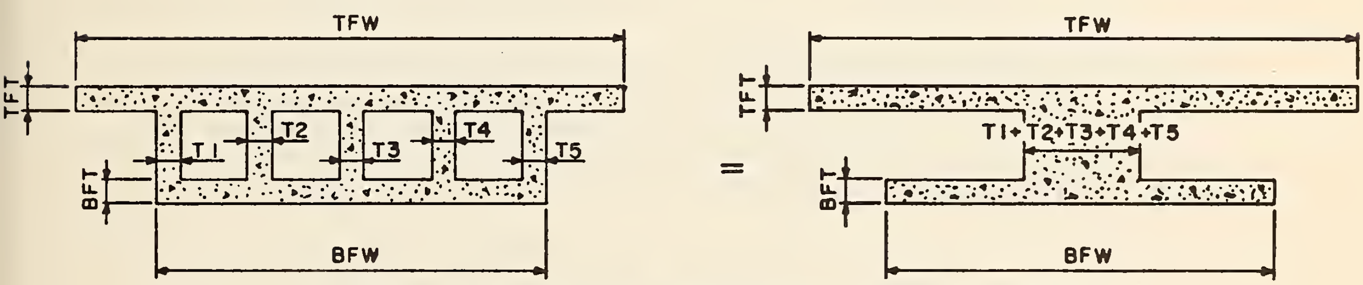
d. Steel and Timber Design. The equations are standard elastic analysis equations, such as:

$$f = \frac{Mc}{I} \text{ and } f_v = \frac{VQ}{IB}$$

The stress reductions are found in the American Association of State Highway Officials publication, "Standard Specifications for Highway Bridges", Tenth Edition.

3.3.3 Description of Input. The input for this component depends a great deal upon the type of section input into the "Structural Analysis" component. Figure 45 indicates all of the dimensions possible for a section to have. A designer may ask himself, "How about a built-up section, consisting of plates, angles, channels, etc?". How this can be accomplished is best shown by figures.

First of all, it must be understood that the structure analysis is for a structure in a single plane. That is, there are no deformations considered in the "z" direction. With this in mind, we can understand how the Figures 67 and 68 are valid assumptions.

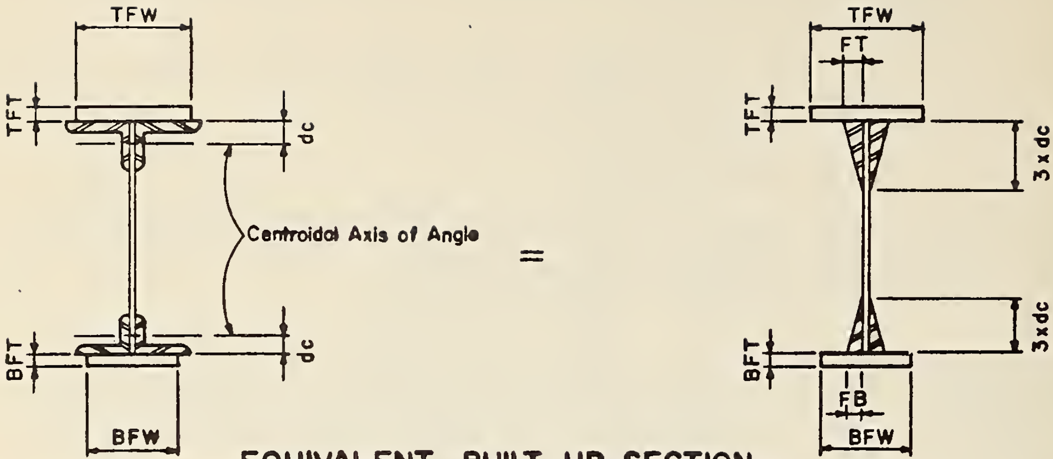


EQUIVALENT FULL SECTION OF BOX GIRDER

Figure 67

Figure 67 shows how to input a box girder section into the system. If this had been the section used in the analysis, then the reinforcing steel required in a design run and the stresses will be for the complete section. When reviewing this structure, the input reinforcing would be all the steel placed in the deck and lower slab that ran parallel to the axis of the structure. If, on the other hand, a person would want to design or review an exterior or interior girder, the analysis input, wheel fractions, superimposed dead loads and reinforcing data would be for one such girder.

On steel bridges that are built of rolled sections and riveted or welded together, some minor calculations will be required by the user. Figure 68 shows a typical steel girder section and the dimensions that are required for input.



EQUIVALENT BUILT UP SECTION

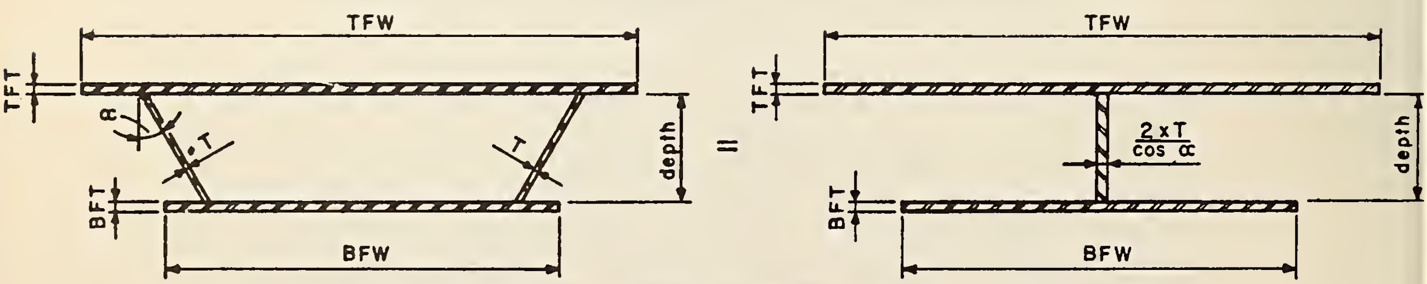
Figure 68

The dimensions FT and FB can be shown to be equal to

$$F = \frac{2\text{Area}}{3(dc)}$$

Where Area = the cross section area of the angle
dc = the distance to the centroid of the angle
F = FT or FB

On steel box girders, the web is not always vertical and may consist of two members. Figure 69 indicates the proper method of calculating the web thickness and depth. The designer would enter the thickness of web equal to two times the actual thickness, divided by the cosine of the angle of inclination of the web.

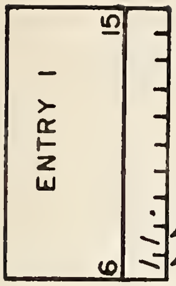


EQUIVALENT FULL SECTION OF STEEL BOX GIRDER

Figure 69

The "Work Code" entry, "DC", is made only once.

a. Data Code 005 calls for the following entries.



Entry #1 asks which output report is desired by the designer. A number "1" shall be entered for each report desired. Both reports may be requested.

Rating Report
Design Report

Entry #2 determines the type of control to be placed upon the computer run. When a rating report is requested in Entry #1, enter a "1". When a design and review report is requested in Entry #1, enter a "0".

Entry #3 is completed when a composite section is being analyzed. This entry determines whether the computer run is for a dead or live load analysis of a composite section.

b. Data Code 501 asks for the material factors used in the design, review and Inventory Rating. These entries allow the reviewer to take into account any reduced condition ratings found in the structural members. The condition rating is considered when establishing the value used for the allowable stresses.

Entry #1 is the materials factor for

$$\text{reinforcing steel (beams)} = \frac{\text{Allowable stress, reinforcing steel}}{\text{Yield stress, reinforcing steel}}$$

Entry #2 is the materials factor for

$$\text{reinforcing steel (columns)} = \frac{\text{Allowable stress, reinforcing steel}}{\text{Yield stress, reinforcing steel}}$$

Entry #3 is the materials factor for

$$\text{concrete members} = \frac{\text{Allowable stress, concrete}}{\text{Ultimate stress, concrete}}$$

Entry #4 is the materials factor for

$$\text{structural steel members} = \frac{\text{Allowable stress, structural steel}}{\text{Yield stress, structural steel}}$$

Entry #5 is the materials factor for

$$\text{timber members} = \frac{\text{Allowable stress, timber}}{\text{Design stress, timber}}$$

The timber design stress, the stress used in designing the structure, is used for timber, since the design of timber members is based on a safe working stress which is not based on a percentage of a yield stress.

c. Data Code 502 asks for the same entries as Data Code 501, except that the factors are used in determining the Operating Rating.

d. Data Code 510 calls for all the sections that were used in

the "Structural Analysis" routine to be defined.

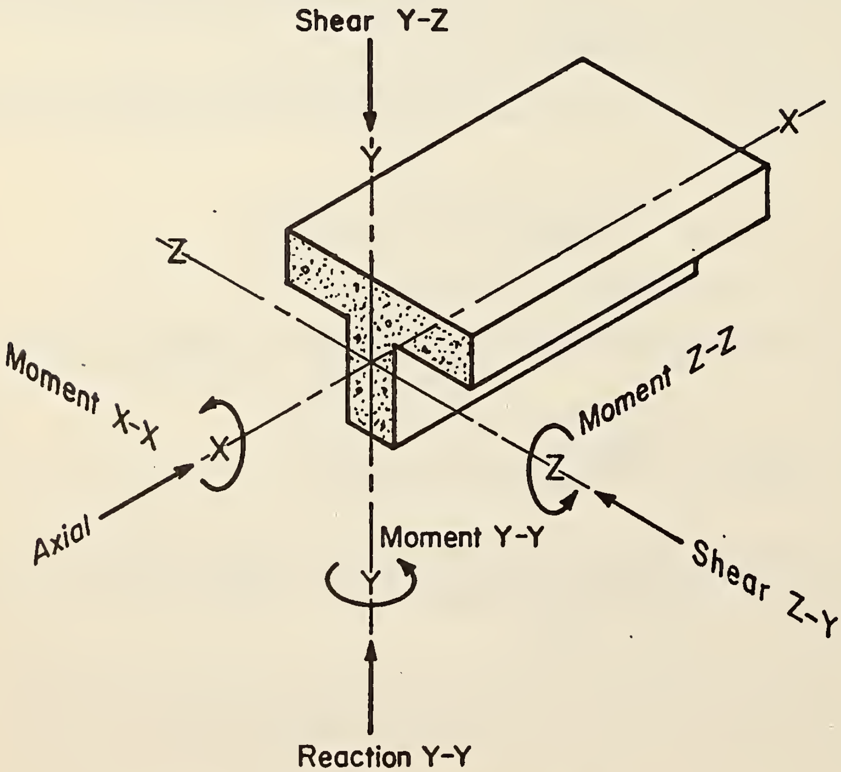
Entries #1, #3 and #5 ask for the section numbers (as numbered in the "Structural Analysis" coding).

Entries #2, #4 and #6 ask for the section type description.

1 = Steel, rolled or built-up section (welded or riveted plate)
3 = Concrete, reinforced
5 = Composite, concrete and steel
7 = Timber

e. Data Code 520 may be used to request critical points in the members at which a review or design is desired, if not previously requested by the 100 series cards. The tenth points are entered as 205, 206, etc. Maximum number of points that may be called for is 18. A 520 card may be repeated if more than six points are desired.

f. Data Code 521 and 522 are used to apply any moments, shears or loads (in addition to those caused by the live and dead loads applied in the "Structural Loading" routine) to the member that may be desired. (An example would be the centrifugal force in curved girders.) Maximum number of cards that may be used is 18. The point numbers would correspond to those of Data Code 520 or 100. The axis notations and actions are depicted in Figure 70.



AXIS OF MEMBER

Figure 70

g. Data Code 523 is used to add moments of inertia to be used in designing or reviewing members that have loads in more than one direction.

h. Data Code 530 is used when a structural steel section is being designed or reviewed. Entries #2 thru #6 have repeat capabilities; that is, they need not be entered for subsequent points after the first point is defined, providing that the section at the subsequent points is the same as the previous one entered.

Entry #1 asks for the number of the point in question, corresponding to a point number on the 100 or 520 card.

Entry #2 asks that the type of section be defined.

2 = rolled or welded plate section
3 = riveted
4 = composite

Entry #3 asks for the yield strength of the steel used for the web, in pounds per square inch.

Entry #4 asks for the yield strength of the steel used for the bottom flange, in pounds per square inch. Do not enter if it is the same as the yield strength of the web.

Entry #5 asks for the yield strength of the steel used for the top flange, in pounds per square inch. Do not enter if it is the same as the yield strength of the web.

Entry #6 asks for the ratio of moduli of elasticity of steel to concrete (n) for composite sections.

i. Data Code 531 continues the description of the steel section. Code a "1" in column 66 of the 530 card when using a 531 card.

Entry #1 asks for the angle of the web from vertical, in degrees and decimals of degrees.

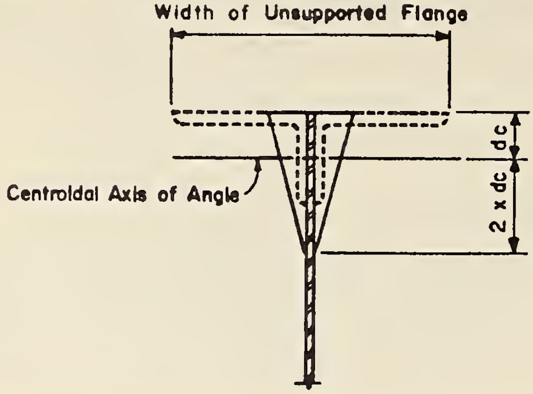
Entry #2 asks for the transverse stiffener spacing, in inches. This may be entered if a check is desired on the stiffener spacing.

Entries #3 and #4 describe the area of the bearing stiffener. These entries are made if a rating is desired for the bearing stiffeners. Each entry is input in inches.

Entry #5 asks if there are longitudinal stiffeners. If the section has a longitudinal stiffener, enter a number "1", and if the section does not have a longitudinal stiffener, enter a "0".

Entry #6 asks for the unsupported length of the compression member, in feet.

When reviewing or designing built-up sections and there are no flanges entered, such as shown in Figure 71, and the section will have an unsupported flange length not equal to zero, then a compression flange width will have to be entered. See Entries #3 and #4 of the 111 card. If the flange width is not entered, no reduction will be taken in the allowable stress.



BUILT-UP SECTION WITH NO FLANGES

Figure 71

This card is not required when the web is vertical and there are no longitudinal stiffeners.

j. Data Code 532 continues the description of the steel section and is used only if there is torsion (Mtxx) involved. Code a "1" in column 66 of the previous card if this data card is used.

Entry #1 defines the type of section. Examples of an open section would be an I-Beam or channel, while the closed section would be a tube.

1 = open type
2 = closed type

Entry #2 is the radius of the fillet connecting the flange with the web, in inches. This is used in calculating stresses.

k. Data Code 533 is also a continuation of the steel section description if the section is either composite or has cover plates. Code a "1" in column 66 of the previous card if this data card is used.

Entry #1 is the allowable shear at the bottom of the top cover plate or composite section, in pounds per lineal inch of beam. This shear may be developed by welds, rivets or shear connectors.

Entry #2 is the allowable shear at the top of the bottom cover plate, in pounds per lineal inch. See Entry #1.

Entry #3 is the ultimate strength of the concrete in compression, in pounds per square inch. This is usually the 28-day breaking strength.

l. Data Code 550 is used when a reinforced concrete section is being designed or reviewed. Entries #2 thru #6 have repeat capabilities; that is, they need not be entered for subsequent points after the first point is defined, providing that the section at the subsequent points is the same as the previous one entered.

Entry #1 asks for the tenth point number of the point in question. This entry must be the same as one of the entries in the 100 or 520 card.

Entry #2 is the yield stress of the main reinforcing steel for the beam or girder, in pounds per square inch.

Entry #3 is the yield stress of the reinforcing steel for stirrups and ties, in pounds per square inch.

Entry # 4 is the ultimate strength of the concrete in compression, in pounds per square inch. This is usually the 28-day breaking strength.

Entry #5 is the percent of concrete to be used in shear normal to the span. In cases where the concrete has no visible cracks, this will be equal to "100". When there are visible failures in the tension side of beams, such as severe spalling and relatively wide shear cracking, this entry should be determined by the engineer inspecting the bridge.

Entry #6 is the ratio of the moduli of elasticity of steel to concrete (n). This entry is used in determining stresses.

m. Data Code 551 is used if this is a design and not a review or rating run. Code a "1" in column 66 of the 550 card when this card is used.

Entry #1 is the distance from the bottom of the section to the centroid of the reinforcing steel, in inches. When you think there will be more than one row of steel required, an average centroidal distance should be entered.

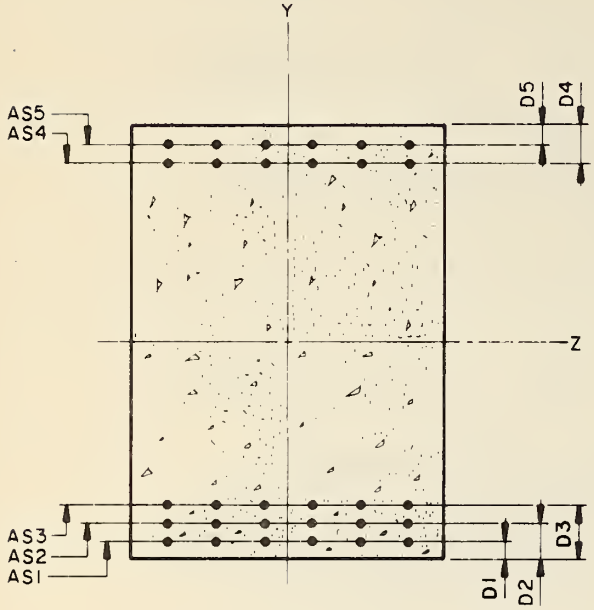
Entry #2 is the distance from the top of the section to the centroid of the reinforcing steel, in inches. See Entry #1.

n. Data Code 552 is used when this is a review or rating run. Code a "1" in column 66 of the 550 card when this card is used. Data codes 551 and 552 are never used in the same run.

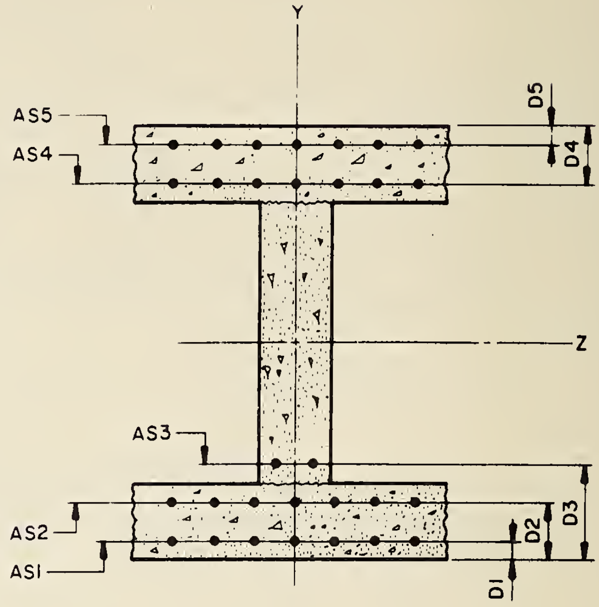
When entering reinforcing steel that is on the compression side of the beam or column, the designer must be certain the reinforcing is truly in the compression area. If it happens to fall outside of the compression area, a significant error will occur in the output. In addition, tension reinforcing that is too close to the neutral axis will cause a decrease in the carrying capacity of the section and should be omitted when reviewing members.

See Figures 72 thru 75 for clarification of reinforcing dimensions.

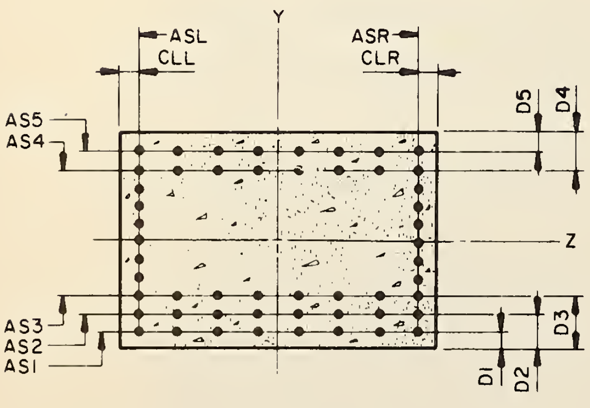
INPUT IDENTIFICATION-REINFORCED CONCRETE BEAMS AND COLUMNS



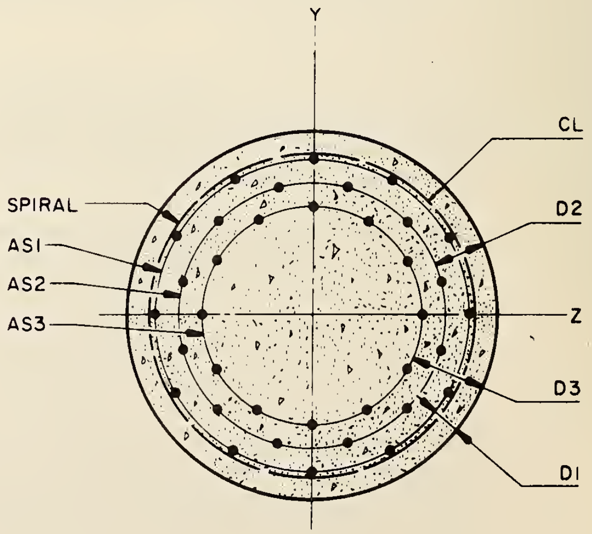
RECTANGULAR BEAM
Figure 72



I OR T BEAM
Figure 73



RECTANGULAR COLUMN
Figure 74



CIRCULAR COLUMN
Figure 75

In the Figures 72 thru 74, the orientation of the section is as follows: On top and bottom spans (1 thru 6 and 14 thru 19), shown in Figures 41 and 42, the AS4 and AS5 reinforcing is always on top regardless of which portion is in tension. In the vertical or inclined spans, the right side is considered to be the top of the beam. See 3.1.1, Ranges and Restrictions, k.

In rectangular columns, Figure 74, since the right side is considered to be the top of the column, it follows that ASL will be on the left side of the section.

Entries #1, #3 and #5 are areas of reinforcing in their respective locations defined by Entries #2, #4 and #6. Areas are input in square inches and distances to centroids in inches.

Entry #1 = AS1	Entry #3 = AS2	Entry #5 = AS3
Entry #2 = D1	Entry #4 = D2	Entry #6 = D3

o. Data Code 553 is used when reviewing or rating a structure that has top steel and/or stirrups to be rated. Code a "1" in column 66 of the previous card. See Figures 72 thru 74 for clarification.

Entry #1 is the area of steel, AS4, in square inches.

Entry #2 is the distance to centroid of AS4, D4, in inches.

Entry #3 is the area of steel, AS5, in square inches.

Entry #4 is the distance to centroid of AS5, D5, in inches.

Entry #5 is the area of steel of stirrups, ties or spiral reinforcement within the space indicated in Entry #6. To determine it, cut the section along the XZ plane and calculate the area of the cut stirrups, ties or spirals, in square inches.

Entry #6 is the space in which the area calculated in Entry #5 is repeated, in inches.

p. Data Code 554 is used when a rectangular or circular reinforced concrete column is being designed or reviewed. Refer to Figure 74 or 75 for clarification. Code a "1" in column 66 of the previous card.

Entry #1 is the area of steel, ASL, in the left side of the column, in square inches.

Entry #2 is the distance, CLL, to the centroid of the reinforcing in the left face, in inches.

Entry #3 is the area of steel, ASR, in the right side of the column, in square inches.

Entry #4 is the distance, CLR, to the centroid of the reinforcing in the right face, in inches.

Entry #5 is a code that denotes the type of shear reinforcement.

1 = ties
2 = spirals

q. Data Code 590 is used when a timber section is being designed or reviewed.

Entry #1 is the tenth point to which the following data will apply. This point will have been previously defined in the 100 or 520 card.

Entry #2 is the design stress of timber in flexure, in pounds per square inch.

Entry #3 is the design stress of timber in horizontal shear, in pounds per square inch.

Entry #4 is the design stress of timber in compression perpendicular to the grain, in pounds per square inch.

Entries #2 thru #4 have repeat capabilities; they need not be entered for subsequent points after the first point is defined, providing that the section at the subsequent points is the same as the previous one entered.

r. Data Code 591 is used for timber sections when the section is over a support. Code a "1" in column 66 of the 590 card.

Entry #1 is the length of the bearing area, in inches.

Entry #2 is the distance from the end of the member to the beginning of the bearing area, in inches.

Entry #3 is the width of the bearing area, in inches.

3.3.4 Description of Output. The output may consist of any of the following printed reports, depending upon the section type and user request:

a. Input verification
b. Reinforced concrete section design/review
c. Structural steel section design/review
d. Timber section design/review
e. Load rating factors
f. Load rating summary sheet

The section design/review reports consist of the following divisions:

a. Point description
b. Input section dimensions
c. Materials factors
d. Applied actions
e. Allowable stresses

	Card 1	Card 2	Card 3	Card 4
ENTRY 6				Type Code
ENTRY 5		Allowable stress over design stress - timber	Allowable stress over design stress - timber	Section Number
ENTRY 4		Allowable stress over yield stress - structural steel	Allowable stress over yield stress - structural steel	Type Code
ENTRY 3	Composite dead load run 0=No, 1=Yes, 2=Composite live load run	Allowable stress over ultimate stress - concrete	Allowable stress over ultimate stress - concrete	Section Number
ENTRY 2	Run Control 0=Design-Review 1=Rating	Allowable stress over yield stress-reinforcing steel (columns)	Allowable stress over yield stress-reinforcing steel (columns	Type Code 1=Steel (welded, rolled or riveted) 3=Concrete, reinforced 5=Composite, steel&concrete 7=Timber
ENTRY 1	Report Request 1 1 Rating Report Design Report	Allowable stress over yield stress-reinforcing steel (beams)	Allowable stress over yield stress-reinforcing steel (beams)	Section Number
DATA CODE	0 0 5 CONTROL CARD	5 0 1 MATERIALS FACTORS (Design, Review or Inventory Rating)	5 0 2 MATERIALS FACTORS (Operating Rating)	5 1 0 SECTION TYPES (Sections as numbered in Structural Analysis) define all sections
WORK CODE	D C			

	Code 520	Code 521	Code 522	Code 523
ENTRY 6	Point Number	Moment-yy Kip/Feet		
ENTRY 5	Point Number	Moment-xx (Torque) Kip/Feet		
ENTRY 4	Point Number	Axial Kips		
ENTRY 3	Point Number	Moment-zz Kip/Feet		
ENTRY 2	Point Number	Shear-yz Kips	Reaction-yy Kips	Moment of Inertia about yy axis Inches^4
ENTRY 1	Point Number	Point Number	Shear-zy Kips	Point Number
DATA CODE	5 2 0 DESIGN POINTS Max. No. = 18 Points	5 2 1 ADD ACTIONS Max. No. cards = 18 See Figure 70	5 2 2 ADD ACTIONS (Continued)	5 2 3 ADD PROPERTIES
WORK CODE				

CONT	1	1	1	
ENTRY 6	Modulus of elasticity ratio - steel to concrete (n)	Unsupported length of compression flange Feet	NOTE: Each group of 530 thru 533 data cards must be in sequence. If 531, 532 and/or 533 cards are required to further define a given point number (Entry #1 of the 530 card) a continue statement, number "1" is required in	
ENTRY 5	Yield stress of top flange (if same as web stress, do not enter) Lbs./Sq. In.	Are there longitudinal stiffeners? 1=Yes 0=No	the "CONT" column of all but the last card in the sequence. It is not necessary, however, that each of the 531 thru 533 cards be required in each group.	
ENTRY 4	Yield stress of bottom flange (if same as web stress, do not enter) Lbs./Sq. In.	Bearing stiffener width Inches	Data cards 550 thru 554 must be coded in a like manner.	
ENTRY 3	Yield stress of web Lbs./Sq. In.	Bearing stiffener thickness Inches		Allowable concrete flexure Lbs./Sq. In.
ENTRY 2	Type Section 2=Rolled Section or Welded Plate 3=Riveted 4=Composite	Transverse stiffener spacing Inches	Radius of fillet Inches	Allowable shear at allowable cover plate Lbs./In.
ENTRY 1	Point Number	Angle of web from vertical Degrees and decimals of degrees	Type of section 1=Open 2=Closed	Allowable shear at composite or upper cover plate Lbs./In.
DATA CODE	5 3 0 STEEL SECTION DETAILS	5 3 1 STEEL SECTION DETAILS - WEB AND STIFFENERS (continued)	5 3 2 STEEL SECTION DETAILS - TORSION (continued)	5 3 3 COMPOSITE AND COVER PLATE SHEARS
WORK CODE				

	Card 1	Card 2	Card 3	Card 4
ENTRY 6	Modulus of elasticity ratio-steel to concrete (n)		Distance to centroid of AS3 (D3) Inches	Spacing of stirrups, ties or spiral reinforcement Inches
ENTRY 5	Percent of concrete to be used in shear normal to the member		Area of steel (AS3) Sq. In.	Area steel stirrups or ties, or spiral reinforcement Sq. In.
ENTRY 4	Ultimate stress of concrete Lbs./Sq. In.		Distance to centroid of AS2 (D2) Inches	Distance to centroid of AS5 (D5) Inches
ENTRY 3	Yield stress of reinforcing steel for stirrups, ties, etc. Lbs./Sq. In.		Area of steel (AS2) Sq. In.	Area of steel (AS5) Sq. In.
ENTRY 2	Yield stress of main reinforcing steel Lbs./Sq. In.	Distance to centroid of steel in top of section Inches	Distance to centroid of ASI (D1) Inches	Distance to centroid of AS4 (D4) Inches
ENTRY 1	Point Number	Distance to centroid of steel in bottom of section Inches	Area of steel (AS1) Sq. In.	Area of steel (AS4) Sq. In.
DATA CODE	5 5 0 DETAILS FOR REINFORCED CONCRETE SECTIONS (Design and Review)	5 5 1 DETAILS FOR REINFORCED CONCRETE SECTIONS (Continued) (Design run only)	5 5 2 DETAILS FOR REINFORCED CONCRETE SECTIONS (Continued) (Review and Rating) See Figures 72-75, p 126	5 5 3 DETAILS FOR REINFORCED CONCRETE SECTIONS (Continued) (Review and Rating)
WORK CODE				

	Code 554	Code 590	Code 591	
CONT		1		
ENTRY 6				
ENTRY 5	Type of shear reinforcement 1=Tie 2= Spiral			
ENTRY 4	Distance to centroid of ASR (CLR) Inches	Design stress of timber in compression perpendicular to grain Lbs./Sq. In.		
ENTRY 3	Area of steel in right end of column (ASR) Sq. In.	Design stress of timber in horizontal shear Lbs./Sq. In.	Width of bearing Inches	
ENTRY 2	Distance to centroid of ASL (CLL) Inches	Design stress of timber in flexure Lbs./Sq. In.	Distance from end of member Inches	
ENTRY 1	Area of steel in left end of section (ASL) Sq. In.	Point Number	Length of bearing Inches	
DATA CODE	5 5 4 DETAILS FOR REINFORCED CONCRETE SECTIONS (Continued) (Column Review)	5 9 0 TIMBER DESIGN	5 9 1 TIMBER BEARING DATA	
WORK CODE				

SUMMARY SHEET

FORM C-16
Rev. 3/11/69

WYOMING STATE HIGHWAY DEPARTMENT
CHEYENNE WYOMING
BRIDGE DIVISION

DESIGN SYSTEM

//EXEC BRSYSØØ

SHEET NO. 1 OF 1
BY ____ DATE ____
CHECKED ____

Employee No. 68	Dept. Code	Par. D	Job Code 75	Work Code	Str. No. 80

1 COMMENT CARD

1ØØ	GIRDER DESIGN, REVIEW, & RATING

WORK CODE (1 2)	DATA CODE (3 5)	ENTRY 1 (6–15)	ENTRY 2 (25)	ENTRY 3 (35)	ENTRY 4 (45)	ENTRY 5 (55)	ENTRY 6 (65)	CONT (66)
D C	0 0 5	Output Control Request (Rating and Design Reports)	Run Control 0=Design/Review 1=Rating	Composite-dead load run 0=No 1=Yes 2=Live load run				
	5 0 1	Ratio, allowable to yield stress--reinf steel (beams)	Ratio, allowable to yield stress--reinf steel (columns)	Ratio, allowable to ultimate stress--concrete	Ratio, allowable to yield stress--structural steel	Ratio, allowable to design stress--timber		
	5 0 2	Ratio, allowable to yield stress--reinf steel (beams)	Ratio, allowable to yield stress--reinf steel (columns)	Ratio, allowable to ultimate stress--concrete	Ratio, allowable to yield stress--structural steel	Ratio, allowable to design stress--timber		
	5 1 0	Section number	Type code	Section number	Type code	Section number	Type code	
	5 2 0	Design point number	Design point number	Design point number	Design point number	Design point number	Design point number	
	5 2 1	Point number for added actions	Shear parallel to yz plane, in y direction	Moment about zz axis	Axial load	Moment about xx axis (torque)	Moment about yy axis	
	5 2 2	Shear parallel to zy plane, in z direction	Reaction parallel to yz plane, in y direction					
	5 2 3	Point number for added properties	Moment of inertia about yy axis					
	5 3 0	Point number for steel section	Type of section 1, 2=Rolled;Welded 3=Riveted 4=Comp	Yield stress of web	Yield stress of bott flange (when ≠ to web stress)	Yield stress of top flange (when ≠ to web stress)	Modulus of elasticity ratio--steel to concrete	1
	5 3 1	Angle of web from vertical	Spacing of transverse stiffeners	Thickness of bearing stiffeners	Width of bearing stiffeners	Longitudinal stiffeners 1=Yes 0=No	Unsupported length of compression flange	1
	5 3 2	Type of section 1=Open 2=Closed	Radius of fillet					1
	5 3 3	Allowable shear at composite or upper cover plate	Allowable shear at lower cover plate	f'_c (composite run only)				
	5 5 0	Point number for reinforced concrete section	Yield stress of main reinf steel in tension	Yield stress of reinf steel for stirrups, ties, etc	Ultimate stress of concrete	Percent of concrete for shear	Modulus of elasticity ratio--steel to concrete	1
	5 5 1	Distance to centroid of steel in bott of section	Distance to centroid of steel in top of section					1
	5 5 2	Area of steel (AS1)	Distance to centroid of AS1 (D1)	Area of steel (AS2)	Distance to centroid of AS2 (D2)	Area of steel (AS3)	Distance to centroid of AS3 (D3)	1
	5 5 3	Area of steel (AS4)	Distance to centroid of AS4 (D4)	Area of steel (AS5)	Distance to centroid of AS5 (D5)	Area of steel for stirrups, ties or spirals	Spacing of stirrups, ties or spirals	1
	5 5 4	Area of steel in left end of section (ASL)	Distance to centroid of ASL (CLL)	Area of steel in right end of section (ASR)	Distance to centroid of ASR (CLR)	Type of shear reinforcement 1=Tie 2=Spiral		
	5 9 0	Point number for timber section	Design stress of timber in flexure	Design stress of timber in horizontal shear	Design stress of timber in compression			1
	5 9 1	Length of bearing	Distance from end of member	Width of bearing				

TRAILER CARD

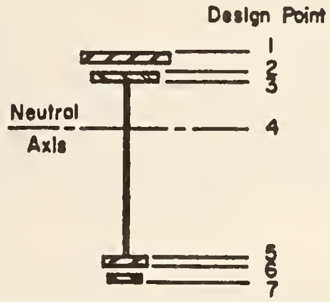
999	

NOTE: A trailer card must follow the last structure card containing data

Figure 76

f. Actual stresses
g. Special design criteria, depending upon the section type.

The actual stresses report refers to design stress points one thru seven, as shown in Figure 77.



DESIGN POINT LOCATIONS

Figure 77

3.4 Matrix Inversion

3.4.1 General Information. This program, "Matrix Inversion" (MB001), will take an array, up to 38 by 38, and produce an inversion for it. It is imperative that the matrix be square; i.e., it must have the same number of rows as it has columns. In addition, no principle diagonal value may be equal to zero. If a zero condition exists, an error message will be typed with the subscript of the diagonal.

The input may consist of a comment card, control card, any number of data cards from one to 999 and a trailer card. The number of cards for one row will be the size of the matrix divided by six, with the number always rounded up to the next whole digit. The total number of input cards will be the number of cards times the size of the matrix. Input may also be called internally by the program from the disk record numbers 135 through 207.

The printed output is achieved by MB001G, which is called internally. The inverted matrix is then recorded on the disk at record numbers 135 through 207, replacing the original input matrix.

3.4.2 Mathematical Derivations. Matrix inversion routine for solution of many equations in many unknowns. Given the matrices

$$\begin{bmatrix} A_{1,1} & A_{1,2} & A_{1,3} & A_{1,4} \\ A_{2,1} & A_{2,2} & A_{2,3} & A_{2,4} \\ A_{3,1} & A_{3,2} & A_{3,3} & A_{3,4} \\ A_{4,1} & A_{4,2} & A_{4,3} & A_{4,4} \end{bmatrix} \quad \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

where the "A" matrix is a coefficient matrix of size m^2 coupled with the identity matrix to make an m by 2m array (let us say mn array).

Using Gauss' method[1] (elimination), with the restriction that no principle diagonal can ever be equal to zero, we have the following:

Step 1

if $A_{1,1} \neq 0$

$C = A_{1,1}$

FORM

$$A_{1,1} = A_{1,1}/C \qquad A_{1,2} = A_{1,2}/C \qquad A_{1,3} = A_{1,3}/C \qquad [A_{1,n} = A_{1,n}/C]^{n}_{n = 1 \to m}$$

[1]Numerical Analysis, Kaiser S. Kunz, McGraw-Hill Book Company, Inc., 1957, Chapter 10

Step 2

$B_1 = A_{2,1}$ $\qquad$ $[A_{2,n} = A_{2,n} - A_{1,n}B]^n$

$n = 1 \rightarrow m$

$A_{2,1} = A_{2,1} - A_{1,1}\,B_1$

$A_{2,2} = A_{2,2} - A_{1,2}\,B_1$

$A_{2,3} = A_{2,3} - A_{1,3}\,B_1$

Step 3

$B_2 = A_{3,1}$ $\qquad$ $[A_{3,n} = A_{3,n} - A_{1,n}B]^n$

$n = 1 \rightarrow m$

$A_{3,1} = A_{3,1} - A_{1,1}\,B_2$

GENERAL

$A_{3,2} = A_{3,2} - A_{1,2}\,B_2$ $\qquad$ $[A_{i,i} = A_{i,j} - A_{1,j}B_j]$

$i = 2 \rightarrow m$
$j = 1 \rightarrow n$

Step 4

if
$A_{2,2} \neq 0$

$C = A_{2,2}$

$A_{2,2} = A_{2,2}/C$ $\qquad$ $[A_{2,n} = A_{2,n}/C]^n$

$n = 2 \rightarrow m$

Step 5

$B_1 = A_{3,2}$ $\qquad$ $[A_{3,n} = A_{3,n} - A_{2,n}B_1]^n$

$n = 2 \rightarrow m$

GENERAL

$A_{3,2} = A_{3,2} - A_{2,2}\,B_1$

$A_{3,3} = A_{3,3} = A_{2,3}\,B_1$ $\qquad$ $[A_{i,j} = A_{i,j} - A_{2,i}B_j]$

$i = 3 \rightarrow m$
$j = 2 \rightarrow n$

until the generated matrix is

$$\begin{bmatrix} 1 & A_{1,2} & A_{1,3} & A_{1,4} \\ 0 & 1 & A_{2,3} & A_{2,4} \\ 0 & 0 & 1 & A_{3,4} \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad \begin{bmatrix} A_{1,5} & A_{1,6} & A_{1,7} & A_{1,8} \\ A_{2,5} & A_{2,6} & A_{2,7} & A_{2,8} \\ A_{3,5} & A_{3,6} & A_{3,7} & A_{3,8} \\ A_{4,5} & A_{4,6} & A_{4,7} & A_{4,8} \end{bmatrix}$$

Step 6

$B = A_{1,2}$ $\qquad [A_{1,n} = A_{1,n} - A_{2,n}B]^n$

$A_{1,2} = A_{1,2} - A_{2,2}\ B$ $\qquad n = 2 \rightarrow m$

$A_{1,3} = A_{1,3} - A_{2,3}\ B$

$A_{1,4} = A_{1,4} - A_{2,4}\ B$

Step 7

$B = A_{1,3}$ $\qquad [A_{1,n} = A_{1,n} - A_{3,n}B]^n$

$A_{1,3} = A_{1,3} - A_{3,3}\ B$ $\qquad n = 3 \rightarrow m$

$A_{1,4} = A_{1,4} - A_{3,4}\ B$

Step 8

$B = A_{2,3}$ $\qquad [A_{2,n} = A_{2,n} - A_{3,n}B]^n$

$A_{2,3} = A_{2,3} - A_{3,3}\ B$ $\qquad n = 3 \rightarrow m$

$A_{2,4} = A_{2,4} - A_{3,4}\ B$

Step 9

$B = A_{1,4}$ $\qquad [A_{1,n} = A_{1,n} - A_{4,n}B]^n$

$A_{1,4} = A_{1,4} - A_{4,4}\ B$ $\qquad n = 4 \rightarrow m$

$A_{1,5} = A_{1,5} - A_{4,5}\ B$

until the generated matrix is

$$\begin{matrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{matrix} \quad \begin{bmatrix} A_{1,1} & A_{1,2} & A_{1,3} & A_{1,4} \\ A_{2,1} & A_{2,2} & A_{2,3} & A_{2,4} \\ A_{3,1} & A_{3,2} & A_{3,3} & A_{3,4} \\ A_{4,1} & A_{4,2} & A_{4,3} & A_{4,4} \end{bmatrix}$$

3.4.3 Description of Input. The input may consist of cards punched from a coded Form C-16 or may be read from the disk at record numbers 135 through 207.

The comment card consists of 77 positions of alphanumeric program identification.

a. The control card contains the work code entry, "MB", and data code entry 001. Entry #1 asks for the matrix size, m.

b. Data Code 001 asks for the matrix elements in sequence in the first row. Each entry contains one element. If the matrix size is of such a nature that additional entries are required for the first row, increment the data code by one, and enter consecutively the next six elements. Repeat this process to a maximum of 38 elements, as required.

c. Upon completing the entries for the first row of the matrix, using the next data code in sequence, repeat the steps listed above for all other rows in the matrix.

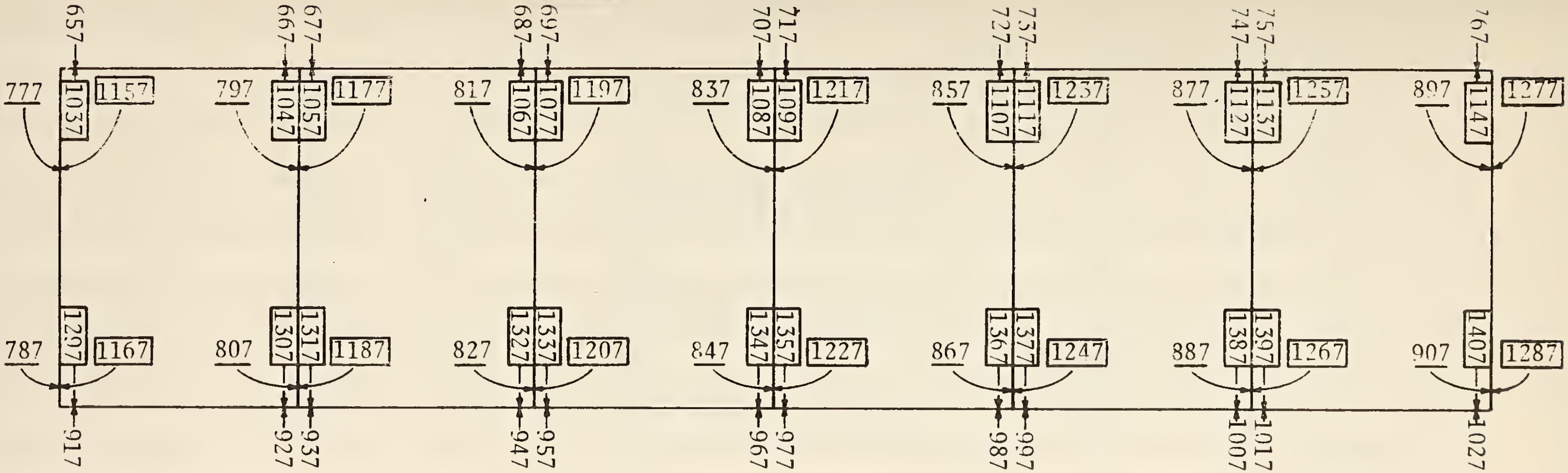
Since the data cards contain an ascending numeric code in the data code field, they must be in ascending order when processing. The total number of input cards is determined by the number of cards in each row times the size of the matrix.

3.4.4 Description of Output. The output is recorded on disk at disk records numbers 135 through 207. When this is recorded, it destroys the original matrix.

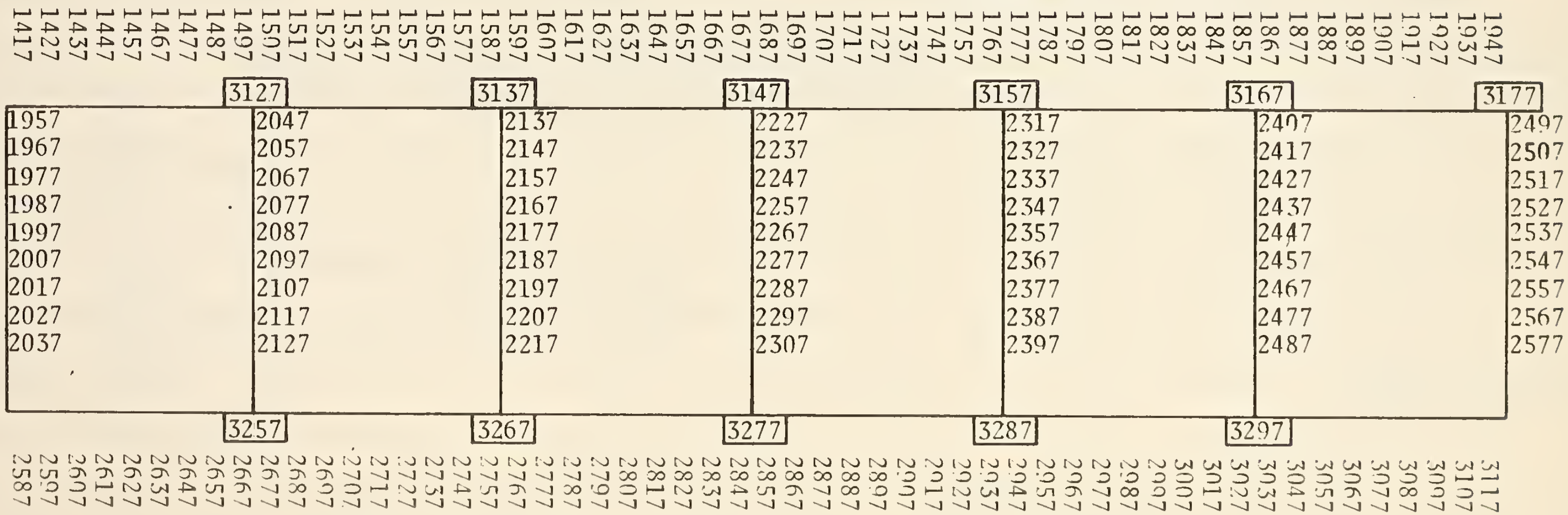
For samples of printed output, with program input, see 4. Sample Problems.

	Card 1	Card 2	Card 3	Card 4
ENTRY 6		Sixth Element of First Row	Twelfth Element of First Row, If Necessary or Sixth Element of Second Row	
ENTRY 5		Fifth Element of First Row	Eleventh Element of First Row, If Necessary or Fifth Element of Second Row	
ENTRY 4		Fourth Element of First Row	Tenth Element of First Row, If Necessary or Fourth Element of Second Row	
ENTRY 3		Third Element of First Row	Ninth Element of First Row, If Necessary or Third Element of Second Row	
ENTRY 2		Second Element of First Row	Eighth Element of First Row, If Necessary or Second Element of Second Row	
ENTRY 1	Matrix Size, m	First Element of First Row	Seventh Element of First Row, If Necessary or First Element of Second Row	
DATA CODE	0 0 1 CONTROL CARD	0 0 1 MATRIX ELEMENTS 1st Row	0 0 2 MATRIX ELEMENTS (continued) Data Code Incremented by 1	0 0 3 MATRIX ELEMENTS (continued) Continuation of first or second row, or first six elements in 3rd row
WORK CODE	M B			

INFLUENCE LINES STORAGE ON DISK



RECORDS THAT END MOMENTS AND SHEARS ARE RECORDED IN (777 Denotes end moments)
($\boxed{1037}$ Denotes shears)



RECORDS THAT STATICAL MOMENTS AND REACTIONS ARE RECORDED IN
2137 is statical moments
$\boxed{3127}$ is reactions

DISK STORAGE OF DATA

PROGRAM	DATA GROUP	VARIABLE NAME	NO OF VAR PER GROUP	WORD NUMBERS	FIRST RECORD NUMBER	LAST RECORD NUMBER	PERM OR TEM.	REMARKS
Basic Str	Span Length	Span Length	19	1-19	1	1	Per	
Analysis	Cell No.	Cell No.	1	20	1	1		Stored by Analysis
DC001	XSec Range	XSec Range	19 Grp of 6	Odd	2		Per	
	& Code	XSec Code	19 Grp of 6	Even		13	Per	
	XSec Input							
	Data	XSec No.	10grp of 1	1-15,9,3-17,11,5-19,13,7	14			1-15=1st&15thword
		B1		2-16,10,4-18,12,6-20,14,				in 14th Record,
				8				9 word
		B2		3-17,11,5-19,13,7,1-15,				in 15th Record
				9				etc.
		B3		4-18,12,6-20,14,8,2-16,				
				10				
		T1		5-19,13,7,1-15,9,3-17,				
				11				
		T2		6-20,14,8,2-16,10,4-18,				
				12				
		F1		7,1-15,9,3-17,11,5-19,13				
		F2		8,2-16,10,4-18,12,6-20,14				

DISK STORAGE OF DATA

PROGRAM	DATA GROUP	VARIABLE NAME	NO OF VAR PER GROUP	WORD NUMBERS	FIRST RECORD NUMBER	LAST RECORD NUMBER	PERM OR TEM.	REMARKS
		F3		9,3-17,11,5-19,13,7,				
				1-15				
		F4		10,4-18,12,6-20,14,8,				
				2-16				
		F5		11,5-19,13,7,1-15,9,				
				3-17				
		F6		12,6-20,14,8,2-16,10,				
				4-18				
		F7		13,7,1-15,9,3-17,11,				
				5-19				
		F8	1Ø Grps of 1	14,8,2-16,10,4-18,12,				
				6-20		20		
	Beam Depths	Depths	19 Spans	21-1,27-1,33-1,39-1,	21			Word=21 Record
	Moments of		W/21	45-1,51-1,57-1,63-1,				First
	Inertia &			69-1,75-1,81-1,87-1,				Word & 21 Con-
	Characteris-			93-1,99-1,105-1,111-1,				sec. words
	tics			117-1,123-1,129-1				
		Areas	19 Spans	22-2,28-2,34-2,40-2,				There is 13 blanks

DISK STORAGE OF DATA

PROGRAM	DATA GROUP	VARIABLE NAME	NO OF VAR PER GROUP	WORD NUMBERS	FIRST RECORD NUMBER	LAST RECORD NUMBER	PERM OR TEM.	REMARKS
			W/21	46-2,52-2,58-2,64-2,				in every 6th.
				70-2,76-2,82-2,88-2,				Record ie; 26,
				94-2,100-2,106-2,112-2,				32,38,44,50,56,
				118-2,124-2,130-2				62,68,74,80,86,
		XBars	19 Spans	23-3,29-3,35-3,41-3,				92,98,104,110,
			W/21	47-3,53-3,59-3,65-3,				116,122,128,
				71-3,77-3,83-3,89-3,				134
				95-3,101-3,107-3,113-3,				
Analysis	Beam Depths	Moment of I	19 Spans	24-4,30-4,36-4,42-4,				
	& Moments		W/21	48-4,54-4,60-4,66-4,				
	of Inertia			72-4,78-4,84-4,90-4,				
				96-4,102-4,108-4,114-4,				
				120-4,126-4,132-4				
		K Left	19 Spans	25-5,31-5,37-5,43-5,				
			W/1	49-5,55-5,61-5,67-5,				
				73-5,79-5,85-5,91-5,				
				97-5,103-5,109-5,115-5,				
				121-5,127-5,133-5				

DISK STORAGE OF DATA

PROGRAM	DATA GROUP	VARIABLE NAME	NO OF VAR PER GROUP	WORD NUMBERS	FIRST RECORD NUMBER	LAST RECORD NUMBER	PERM OR TEM.	REMARKS
		K Right	19 Spans	25-6,31-6,37-6,43-6,				
			W/1	49-6,55-6,61-6,67-6,				
				73-6,79-6,85-6,91-6,				
				97-6,103-6,109-6,115-6,				
				121-6,127-6,133-6				
		C Left	19 Spans	25-7,31-7,37-7,43-7,				
			W/1	49-7,55-7,61-7,67-7,				
				73-7,79-7,85-7,91-7,				
				97-7,103-7,109-7,115-7,				
				121-7,127-7,133-7				
		C Right	19 Spans	25-8,31-8,37-8,43-8,				
			W/1	49-8,55-8,61-8,67-8,				
				73-8,79-8,85-8,91-8,				
				97-8,103-8,109-8,115-8,				
				121-8,127-8,133-8				
		FEM Right	19 Spans	25-9,31-9,37-9,43-9,				
			W/9	49-9,55-9,61-9,67-9,				
				73-9,79-9,85-9,91-9,				
				97-9,103-9,109-9,115-9,				

DISK STORAGE OF DATA

PROGRAM	DATA GROUP	VARIABLE NAME	NO OF VAR PER GROUP	WORD NUMBERS	FIRST RECORD NUMBER	LAST RECORD NUMBER	PERM OR TEM.	REMARKS
				121-9,127-9,133-9				
		FEM Left	19 Spans	25-18,31-18,37-18,				
			W/9	43-18,49-18,55-18,				
				61-18,67-18,73-18,				
				79-18,85-18,91-18,				
				97-18,103-18,109-18,				
				115-18,121-18,127-18,				
				133-18		134		
		Case Type	19 Spans	26-7,32-7,38-7,44-7,				0=Parabolic
			W/1	50-7,56-7,62-7,68-7,				
				74-7,80-7,86-7,92-7,				
				98-7,104-7,110-7,116-7,				
				122-7,128-7,134-7				
	Matrix	A(I,J)		I varies First A(1,39),	135			
	Inversion	I=1,38		A(2,39), A(3,39)----				
		J=39,76		A(38,39) A(1,40)----				
				A(38,40)----A(38,76)		207-4		16 blank in Rec.
								207
DC511	VYE,MZZ,RYZ AREAS	14,23 A(I,J)	322		208		Tem	By Span 19 Grps.

DISK STORAGE OF DATA

PROGRAM	DATA GROUP	VARIABLE NAME	NO OF VAR PER GROUP	WORD NUMBERS	FIRST RECORD NUMBER	LAST RECORD NUMBER	PERM OR TEM.	REMARKS
					225			Span #2
					242			#3
					259			#4
					276			#5
					293			#6
					310			#7
					327			#8
					344			#9
					361			#10
					378			#11
					395			#12
					412			#13
					429			#14
					446			#15
					463			#16
					480			#17
					497			#18
					514			Span #19
						530		

DISK STORAGE OF DATA

PROGRAM	DATA GROUP	VARIABLE NAME	NO OF VAR PER GROUP	WORD NUMBERS	FIRST RECORD NUMBER	LAST RECORD NUMBER	PERM OR TEM.	REMARKS
DC101	Stiffness	A(I,J)	57		531		Per	(KL,CL,KR)
	& Carry-					533		Grouped as such
	overs							

DISK STORAGE OF DATA

PROGRAM	DATA GROUP	VARIABLE NAME	NO OF VAR PER GROUP	WORD NUMBERS	FIRST RECORD NUMBER	LAST RECORD NUMBER	PERM OR TEM.	REMARKS
Bridge								
Executive	Control	WC	1	1	548		Tem	Reserve 548 thru
	Card	DC	1	2				580 for Bridge
		EC(I)I-1,6	6	3,4,5,6,7,8				Exec
		NZ	1	9 Page No.		548		Page No.
DC001R		Alph 3	1					Cant Leg #3 Angle
DC001R		Alph 4	1					Cant Leg #4 Angle
Executive		EMP	1	13				Employee Number
Cont.		Dept	1	14				Department Code
		Work	1	15				Production or Develop. Code
		Job	1	16				Project Code
		WRKTYP	1	17				Work Type "Det", etc.
		STR	1	18				Structure or Program No.
		SAV1	1	19		548		Beginning of Job time
	Comment	ACOM	19	1-19	549			
	Card	BCOM	1	20		549	Tem	

DISK STORAGE OF DATA

PROGRAM	DATA GROUP	VARIABLE NAME	NO OF VAR PER GROUP	WORD NUMBERS	FIRST RECORD NUMBER	LAST RECORD NUMBER	PERM OR TEM.	REMARKS
All Programs	Control	WC,DC,ED		1 thru 8	550		Perm	Next Control
	Card	(I)I=1,6				550		Card read
		NZ & NNZ	1	9 & 10	550	550		Page & Line
								Counter
DC501	Effective	NN(I)	19	Array of Spans	551		Perm	
	Spans	I=1,19		1 to No of Spans		551		
Exec	Comment							
	Card	WT(3)		Total Truck Weights	552			17 Spare

DISK STORAGE OF DATA

PROGRAM	DATA GROUP	VARIABLE NAME	NO OF VAR PER GROUP	WORD NUMBERS	FIRST RECORD NUMBER	LAST RECORD NUMBER	PERM OR TEM.	REMARKS
Beam Depths	Web Widths	Web(N,J)	21	Span 1 (63 consec.words)	581			
DC101	Top Flange	FTGT(N,J)	21			584		17 Blanks in 584
	Thickness							
	Bot Flange							
	Thickness	FTGB(N,J)	21	Span 2	585			
						588		7 Blanks in 588
				Span 3	589			
						592		
				Span 4	593			
						596		
				Span 5	597			
						600		
				Span 6	601			
						604		
				Span 7	605			
						608		
				Span 8	609			
						612		
				Span 9	613			

DISK STORAGE OF DATA

PROGRAM	DATA GROUP	VARIABLE NAME	NO OF VAR PER GROUP	WORD NUMBERS	FIRST RECORD NUMBER	LAST RECORD NUMBER	PERM OR TEM.	REMARKS
						616		
				Span 10	617			
						620		
				Span 11	621			
						624		
				Span 12	625			
						628		
				Span 13	629			
						632		
				Span 14	633			
						636		
				Span 15	637			
						64Ø		
				Span 16	641			
						644		
BM Depths	WEB Widths	WEB (J)	21	Span #17	645			
	FLNG Thick	FTGT (J)	21			648		17 Blanks in 648
	(Top)							
	FLNG. Thick	FTGB (J)	21	Span #18	649			

DISK STORAGE OF DATA

PROGRAM	DATA GROUP	VARIABLE NAME	NO OF VAR PER GROUP	WORD NUMBERS	FIRST RECORD NUMBER	LAST RECORD NUMBER	PERM OR TEM.	REMARKS
	Bottom					652		17 Blanks in 652
				Span #19	653			
						656		17 Blanks in 656
STATICS	MZZ End Mom.	E(I,J,N)	191	Span 1 & 2 in Consect.	657			EM(1.0L 1
DC501		N=Load		Span 3 & 4	658			
				Span 5 & 6	659			
				Span 7 & 8	660			
				Span 9 & 10	661			
				Span 11 & 12	662			
				Span 13 & 14	663			
				Span 15 & 16	664			
				Span 17 & 18	665			
				Span 19 & 20	666			
Left End Moment Record No. = Span No. x 20 + 637								
Right End Moment Record No. = Span No. x 20 + 647								
For Cell = 10 this data overlays End Moment Influence Lines					947			θA
					957			θB
					967			θC

DISK STORAGE OF DATA

PROGRAM	DATA GROUP	VARIABLE NAME	NO OF VAR PER GROUP	WORD NUMBERS	FIRST RECORD NUMBER	LAST RECORD NUMBER	PERM OR TEM.	REMARKS
					977			θD
					987			θE
					997			θF
					1007			Δ
					1017			R_D
					1027	1036		R_F
Note: Cell 10 & 11 Areas for θ, Δ, and R's								
STATICS	Shears	V(J,I,N)	191	Span 1 & 2 in Consect.	1037			1.0L
				Span 3 & 4				
				Span 5 & 6				
				Span 7 & 8				
				Span 9 & 10				
				Span 11 & 12				
				Span 13 & 14				
				Span 15 & 16				
				Span 17 & 18				
				Span 19 & 20				
Left End Shear Record No. = Span No. x 20 + 1017 Right End Shear Record No. = Span No. x 20 +1027								

DISK STORAGE OF DATA

PROGRAM	DATA GROUP	VARIABLE NAME	NO OF VAR PER GROUP	WORD NUMBERS	FIRST RECORD NUMBER	LAST RECORD NUMBER	PERM OR TEM.	REMARKS
STATICS	MZZ Static Mom.	SM(J,I,N)	191	As End Moments	1417			SM(1.1)
Record No. for Statical Moments = RSM								
RSM = Span No. x 90 + Tenth Point x 10 + 1317								
For Cell = 11 this data overlays Statical Moment Influence								
					2587			Cell 11 SM 14.1 ϕK
					2597			SM 14.2 Δ
					2607			SM 14.3 R_D
					2617			SM 14.4 R_F
					2627			SM 14.5 R_H
					2637			SM 14.6 R_J
AREAS	RYZ Reactions	R ( )	191		3127			RC 1
DC501				Span 1 & 2 in Consect.				
				Span 3 & 4				
				Span 5 & 6				
				Span 7 & 8				
				Span 9 & 10				
				Span 11 & 12				
				Span 13 & 14				

DISK STORAGE OF DATA

PROGRAM	DATA GROUP	VARIABLE NAME	NO OF VAR PER GROUP	WORD NUMBERS	FIRST RECORD NUMBER	LAST RECORD NUMBER	PERM OR TEM.	REMARKS
				Span 15 & 16				
				Span 17 & 18				
				Span 19 & 20				
Record No.	for Reaction	= RR						
RR = Span	No. x 10 + 31	17						
D.L. MOM.	MOM. V.R.	Mom.	72	11 Girder Moments 11 Super. Moments	3307			
		Shear		11 Point Moments 11 Girder Shears				
		React		11 Super. Shears 11 Point Shears				
				1-Left Girder Reaction 1-Left Super. Reaction				
				1-Left Point Reaction 1-Right Girder Reac.				
				1-Right Super. Reac. 1-Right Point Reaction		3310		
Record No.	for Statical	Moments =	Span No. x 4	+3303				
D.L. MOM.	Reactions	React	3	1, 2, 3	3383	3383		
DEFLECTIONS	Live Load	D(I,J)			3384			Span #1
	Inf. Lines & Dead			1 - 99 100 Skip				
	Load Defl-	DLDF(I)				3389		
	ections			101 - 111 112 - 120 Skip				

DISK STORAGE OF DATA

PROGRAM	DATA GROUP	VARIABLE NAME	NO OF VAR PER GROUP	WORD NUMBERS	FIRST RECORD NUMBER	LAST RECORD NUMBER	PERM OR TEM.	REMARKS
Recrod No. for Deflections = Span No. x 6 + 3378								
DEFLECTIONS					3492			Span #19
						3497		
LIVE LOAD DEFLECTIONS		DL(I)	191	1 - 191	3498			Lane Load Deflections
						3507		
		DM(I)	191	1 - 191	3508			Military Load Deflections
						3517		
		DT(I)	191		3518			Truck Load Deflections
						3527		
DEAD LOAD MOMENT(READ)	1 Girder Wt./Ft.[3]	Unit		1	3528			
	Modulus of Elast. ESUBG			2				
	19 Uniform Loads	UDL(I)		3 - 21		3529		19 blanks Recrod 3529
	216 Point Loads	P(K)		1 -216	3530	3540		
	Live Loading	XN(I)		1 - 10	3541	3541		
Dead Load Moment	Min Uniform Weight	WT(I)		1 - 19	3542			
	Total Spans	USP		20		3542		
DC401	Matrix	A(I,J)	2888	1 - 2888	3373		Temp	360 Only
DC003 BYSYS24	Truck Overload		24	1 - 24	3543	3545		

DISK STORAGE OF DATA

PROGRAM	DATA GROUP	VARIABLE NAME	NO OF VAR PER GROUP	WORD NUMBERS		FIRST RECORD NUMBER	LAST RECORD NUMBER	PERM OR TEM.	REMARKS
BRFGCA	X COORD	X	108	X(1,1)	X(12,9)	4000	4005	TEM	126 in 4005
"	Y COORD	Y	108	Y(1,1)	Y(12,9)	4006	4011	"	126 in 4011
"	SPIRAL LEN	S	108	S(1,1)	S(12,9)	4012	4017	"	126 in 4017
"	DIAG LEN	DL	99	DL(1,1)	DI(11,9)	4018	4022	"	16 in 4022
"	GIRD LEN	GL	96	GL(1,1)	GL(12,8)	4023	4027	"	46 in 4027
"	OFFSETS	OFST	108	OFST(1,1)	OFST(12,9)	4028	4033	"	126 in 4033
BRFGCB	LINE 1	X1Ø	72	X10(1)	10(72)	4034	4037	"	86 in LAST REC
"	LINE 2	"	"	"		4038	4041	"	"
"	LINE 3	"	"	"		4042	4045	"	"
"	LINE 4	"	"	"		4046	4049	"	"
"	LINE 5	"	"	"		4050	4053	"	"
"	LINE 6	"	"	"		4054	4057	"	"
"	LINE 7	"	"	"		4058	4061	"	"
"	LINE 8	"	"	"		4067	4065	"	"
"	LINE 9	"	"	"		4066	4069	"	"
"	LINE 1Ø	"	"	"		4070	4073	"	"
"	LINE 11	"	"	"		4074	4077	"	"
"	LINE 12	"	"	"		4078	4081	"	"

DISK STORAGE OF DATA

PROGRAM	DATA GROUP	VARIABLE NAME	NO OF VAR PER GROUP	WORD NUMBERS	FIRST RECORD NUMBER	LAST RECORD NUMBER	PERM OR TEM.	REMARKS
BRFGCB	LINE 1	Y1∅	72	Y10(1) X10(72)	4082	4085	"	8b in last Rec
"	LINE 2	"	"	"	4086	4089	"	"
"	LINE 3	"	"	"	4090	4093	"	"
"	LINE 4	"	"	"	4094	4097	"	"
"	LINE 5	"	"	"	4098	4101	"	"
"	LINE 6	"	"	"	4102	4105	"	"
"	LINE 7	"	"	"	4106	4109	"	"
"	LINE 8	"	"	"	4110	4113	"	"
"	LINE 9	"	"	"	4114	4117	"	"
"	LINE 10	"	"	"	4118	4121	"	"
"	LINE 11	"	"	"	4122	4125	"	"
"	LINE 12	"	"	"	4126	4129	"	"
BRFGCB	LINE 1	S1	72	S1(1) S1(72)	4130	4133	Tem	8b in last Rec.
"	LINE 2	"	"	"	4134	4137	"	"
"	LINE 3	"	"	"	4138	4141	"	"
"	LINE 4	"	"	"	4142	4145	"	"
"	LINE 5	"	"	"	4146	4149	"	"

DISK STORAGE OF DATA

PROGRAM	DATA GROUP	VARIABLE NAME	NO OF VAR PER GROUP	WORD NUMBERS		FIRST RECORD NUMBER	LAST RECORD NUMBER	PERM OR TEM.	REMARKS
BRFGCB	LINE 6	S1	72	S1(1)	S1(72)	4150	4153	TEM	8b in last Rec.
"	LINE 7	"	"	"		4154	4157	"	"
"	LINE 8	"	"	"		4158	4161	"	"
"	LINE 9	"	"	"		4162	4165	"	"
"	LINE 10	"	"	"		4166	4169	"	"
"	LINE 11	"	"	"		4170	4173	"	"
"	LINE 12	"	"	"		4174	4177	"	"
BRFGCB	LINE 1	OST	72	OST(1)	OST(72)	4178	4181	"	"
"	LINE 2	"	"	"		4182	4185	"	"
"	LINE 3	"	"	"		4186	4189	"	"
"	LINE 4	"	"	"		4190	4193	"	"
"	LINE 5	"	"	"		4194	4197	"	"
"	LINE 6	"	"	"		4198	4201	"	"
"	LINE 7	"	"	"		4202	4205	"	"
"	LINE 8	"	"	"		4206	4209	"	"
"	LINE 9	"	"	"		4210	4213	"	"
"	LINE 10	"	"	"		4214	4217	"	"
"	LINE 11	"	"	"		4218	4221	"	"

DISK STORAGE OF DATA

PROGRAM	DATA GROUP	VARIABLE NAME	NO OF VAR PER GROUP	WORD NUMBERS		FIRST RECORD NUMBER	LAST RECORD NUMBER	PERM OR TEM.	REMARKS
BRFGCB	LINE 12	OST	72	OST(1)	OST(72)	4222	4225′	TEM	8b in last Rec.
BRFGCC	LENGTHS	AL1,AL2,AL3, AL4, FEE	5			4226	4226	"	15 blanks
"	ALL X INTER-Sects	XW	108	XW(1)	XW(108)	4227	4232	"	12 b in last Rec
"	ALL Y INTER-Sects	YW	108	YW(1)	YW(108)	4233	4238	"	12 b in last Rec
"	LINE 1	XW	72	XW(1)	XW(72)	4239	4242		
"	LINE 2	"	"	"		4243	4246		
"	LINE 3	"	"	"		4247	4250		
"	LINE 4	"	"	"		4251	4254		
"	LINE 5	"	"	"		4255	4258		
BRFGCC	LINE 6	XW	72	XW(1)	XW(72)	4259	4262		
"	LINE 7	"	"	"		4263	4266		
"	LINE 8	"	"	"		4267	4270		
"	LINE 9	"	"	"		4271	4274		
"	LINE 10	"	"	"		4275	4278		
"	LINE 11	"	"	"		4279	4282		
"	LINE 12	"	"	"		4283	4286		

DISK STORAGE OF DATA

PROGRAM	DATA GROUP	VARIABLE NAME	NO OF VAR PER GROUP	WORD NUMBERS	FIRST RECORD NUMBER	LAST RECORD NUMBER	PERM OR TEM.	REMARKS
BRF6CC	LINE 1	YW	72	YW(1) YW(72)	4287	4290		
"	LINE 2	"	"	"	4291	4294		
"	LINE 3	"	"	"	4295	4298		
"	LINE 4	"	"	"	4299	4302		
"	LINE 5	"	"	"	4303	4306		
"	LINE 6	"	"	"	4307	4310		
"	LINE 7	"	"	"	4311	4314		
"	LINE 8	"	"	"	4315	4318		
"	LINE 9	"	"	"	4319	4322		
"	LINE 10	"	"	"	4323	4326		
"	LINE 11	"	"	"	4327	4330		
"	LINE 12	"	"	"	4331	4334		
BRFGCD	LAYOUT	ELEV	108	ELEV(1,1) ELEV (12,9)	4335	4340	TEM	12b in last Rec.
"	LINE 1	ELEV	72	ELEV (1) ELEV (72)	4341	4344	TEM	8b in last Rec.
"	LINE 2	"	"	"	4345	4348	"	"
"	LINE 3	"	"	"	4349	4352	"	"
"	LINE 4	"	"	"	4353	4356	"	"
"	LINE 5	"	"	"	4357	4360	"	"
"	LINE 6	"	"	"	4361	4364	"	"

DISK STORAGE OF DATA

PROGRAM	DATA GROUP	VARIABLE NAME	NO OF VAR PER GROUP	WORD NUMBERS	FIRST RECORD NUMBER	LAST RECORD NUMBER	PERM OR TEM.	REMARKS
BRFGCD	LINE 7	ELEV	72	ELEV (1) ELEV (72)	4365	4368	Tem	8b in last Rec.
"	LINE 8	"	"	"	4369	4372	"	"
"	LINE 9	"	"	"	4373	4376	"	"
"	LINE 10	"	"	"	4377	4380	"	"
"	LINE 11	"	"	"	4381	4384	"	"
DC003	Span 1	+ML	1	1	4385		"	
		+M.1	1	2			"	
		+M.2	1	3			"	
		+M.3	1	4			"	
		+M.4	1	5			"	
		+M.5	1	6			"	
		+M.6	1	7			"	
		+M.7	1	8			"	
		+M.8	1	9			"	
		+MR	1	10			"	
		-ML	1	11			"	
		-M.1	1	12			"	
		-M.2	1	13			"	
		-M.3	1	14			"	

DISK STORAGE OF DATA

PROGRAM	DATA GROUP	VARIABLE NAME	NO OF VAR PER GROUP	WORD NUMBERS	FIRST RECORD NUMBER	LAST RECORD NUMBER	PERM OR TEM.	REMARKS
DC003	Span 1	-M.4	1	15			Tem	
		-M.5	1	16			"	
		-M.6	1	17			"	
		-M.7	1	18			"	
		-M.9	1	21	4386		"	
		-MR	1	22			"	
		+ML	1	23			"	
		+M.1	1	24			"	
		+M.2	1	25			"	
		+M.3	1	26			"	
		+M.4	1	27			"	
		+M.5	1	28			"	
		+M.6	1	29			"	
		+M.7	1	30			"	
		+M.8	1	31			"	
		+M.9	1	32			"	
		MR	1	33			"	
		-ML	1	34			"	
		-M.1	1	35			"	

DISK STORAGE OF DATA

PROGRAM	DATA GROUP	VARIABLE NAME	NO OF VAR PER GROUP	WORD NUMBERS	FIRST RECORD NUMBER	LAST RECORD NUMBER	PERM OR TEM.	REMARKS
DC003	Span 1	-M.2	1	36			Tem	
		-M.3	1	37			"	
		-M.4	1	38			"	
		-M.5	1	39			"	
		-M.6	1	40			"	
		-M.7	1	41	4387		"	
		-M.8	1	42			"	
		-M.9	1	43			"	
		-MR	1	44			"	
		+ML	1	45			"	
		+M.1	1	46			"	
		+M.2	1	47			"	
		+M.3	1	48			"	
		+M.4	1	49			"	
		+M.5	1	50			"	
		+M.6	1	51			"	
		+M.7	1	52			"	
		+M.8	1	53			"	
		+M.9	1	54			"	

DISK STORAGE OF DATA

PROGRAM	DATA GROUP	VARIABLE NAME	NO OF VAR PER GROUP	WORD NUMBERS	FIRST RECORD NUMBER	LAST RECORD NUMBER	PERM OR TEM.	REMARKS
DC003		+MR	1	55			Tem	
		-ML	1	56			"	
		-M.1	1	57			"	
		-M.2	1	58			"	
		-M.3	1	59			"	
		-M.4	1	60			"	
		-M.5	1	61	4388		"	
		-M.6	1	62			"	
		-M.7	1	63			"	
		-M.8	1	64			"	
		-M.9	1	65			"	
		-MR	1	66			"	
		VL	1	67			"	
		V.1	1	68			"	
		V.2	1	69			"	
		V.3	1	70			"	
		V.4	1	71			"	
		V.5	1	72			"	
		V.6	1	73			"	

DISK STORAGE OF DATA

PROGRAM	DATA GROUP	VARIABLE NAME	NO OF VAR PER GROUP	WORD NUMBERS	FIRST RECORD NUMBER	LAST RECORD NUMBER	PERM OR TEM.	REMARKS
DC003		V.7	1	74			Tem	
		V.8	1	75			"	
		V.9	1	76			"	
		VR	1	77			"	
		VL	1	78			"	
		V.1	1	79			"	
		V.2	1	80			"	
		V.3	1	81	4389		"	
		V.4	1	82			"	
		V.5	1	83			"	
		V.6	1	84			"	
		V.7	1	85			"	
		V.8	1	86			"	
		V.9	1	87			"	
		VR	1	88			"	
		VL	1	89			"	
		V.1	1	90			"	
		V.2	1	91			"	
		V.3	1	92			"	

DISK STORAGE OF DATA

PROGRAM	DATA GROUP	VARIABLE NAME	NO OF VAR PER GROUP	WORD NUMBERS	FIRST RECORD NUMBER	LAST RECORD NUMBER	PERM OR TEM.	REMARKS
DC003		V.4	1	93			Tem	
		V.5	1	94			"	
		V.6	1	95			"	
		V.7	1	96			"	
		V.8	1	97			"	
		V.9	1	98			"	
		VR	1	99			"	
		Truck Reac Left	1	100			"	
		Truck Reac Right	1	101	4390		"	
		Lane React Left	1	102			"	
		Lane React Right	1	103			"	
		Military React Left	1	104			"	
		Military Reac Right	1	105			"	
		Neg Truck Reac Left	1	106			"	
		Neg Truck Reac Rt.	1	107			"	
		Neg Lane Reac Left	1	108			"	
		Neg Lane Reac Rt.	1	109			"	
		Neg Milt Reac Left	1	110			"	

DISK STORAGE OF DATA

PROGRAM	DATA GROUP	VARIABLE NAME	NO OF VAR PER GROUP	WORD NUMBERS	FIRST RECORD NUMBER	LAST RECORD NUMBER	PERM OR TEM.	REMARKS
Record No.	for Liveload	Moments -	Span No. x 6	+4379				
DC501J	Span 1 .1	Shear Infl. Line VI	191	VI = 1 → 191	4529	4539	Temp	6 blanks last record
		Area	23	AREA → 192 → 214				
Record No.	for Shear Influence	Lines =	Span No.	x 90 + Point No. x 10	+ 4429			

DISK STORAGE OF DATA

PROGRAM	DATA GROUP	VARIABLE NAME	NO OF VAR PER GROUP	WORD NUMBERS	FIRST RECORD NUMBER	LAST RECORD NUMBER	PERM OR TEM.	REMARKS
	.8				6289	6299		
	.9				6300	6310		
	span 19 .1				6311	6321		
	.2				6322	6332		
	.3				6333	6343		
	.4				6344	6354		
	.5				6355	6365		
	.6				6366	6376		
	.7				6377	6387		
	.8				6388	6398		
	.9				6399	6409		
GF001	X,Y,&Z coordinates				6410	6485	Perm	
COGO scratch					6486	7499	Tem	
DC101	Fixed end moments for	Left end coef.	19 Spans with one	1-19	7500	7500	Perm	
	uniform loads		coefficient					
		Right end coefficient	19 Spans w/ 1 coef.	20-18		7501		
DC101	Shears from uniform	Left end	9 per span	7502-1,7503-1, etc.	7502		Perm	
	fixed end moments	Right end	9 per span	7502-9,7503-9, etc.		7520		
DC001R	composite data	girder	section	Array(3,10)	7521	7523		

DISK STORAGE OF DATA

PROGRAM	DATA GROUP	VARIABLE NAME	NO OF VAR PER GROUP	WORD NUMBERS	FIRST RECORD NUMBER	LAST RECORD NUMBER	PERM OR TEM.	REMARKS
BRSYS08 DC701	Joint Disp (WL Case 1)	DJ	204		7524	7534	Tem	16 blanks Last Rec.
"	Reactions (WL Case 1	R	204		7535	7545	"	16 blanks Last Rec.
"	Axial Loads (WL Case 1)	AL	200		7546	7555	"	
"	Shears (WL Case 1)	S	200		7556	7565	"	
"	Y Moments (WL Case 1)	YM	200		7566	7575	"	
"	Z Moments (WL Case 1)	ZM	200		7576	7585	"	
"	Joint Disp (WL Case 2)	DJ	204		7586	7596	"	16 blanks Last Rec.
"	Reactions (WL Case 2)	R	204		7597	7607	"	16 blanks Last Rec.
"	Axial Load (WL Case 2)	AX	200		7608	7617	"	
"	Shears (WL Case 2)	S	200		7618	7627	"	
"	Y Moments (WL Case 2)	YM	200		7628	7637	"	
"	Z Moments (WL Case 2)	ZM	200		7638	7647	"	
"	Joint Disp (WL Case 3)	DJ	204		7648	7658	"	16 blanks Last Rec.
"	Reactions (WL Case 3)	R	204		7659	7669	"	16 blanks Last Rec.
"	Axial Load (WL Case 3)	AL	200		7670	7679	"	
"	Shears (WL Case 3)	S	200		7680	7689	"	
"	Y Moments (WL Case 3)	YM	200		7690	7699	"	
"	Z Moments (WL Case 3)	ZM	200		7700	7709	"	
"	Joint Disp (WL Case 3)	DJ	204		7710	7720	"	16 blanks Last Rec.

DISK STORAGE OF DATA

PROGRAM	DATA GROUP	VARIABLE NAME	NO OF VAR PER GROUP	WORD NUMBERS	FIRST RECORD NUMBER	LAST RECORD NUMBER	PERM OR TEM.	REMARKS
BRSYS08 DC701	Reactions (WL Case 4)	R	204		7721	7731	Tem	16 blanks Last Rec.
"	Axial Loads (WL Case 4)	AL	200		7732	7741	"	
"	Shears (WL Case 4)	S	200		7742	7751	"	
"	Y Moments (WL Case 4)	YM	200		7752	7761	"	
"	Z Moments (WL Case 4)	ZM	200		7762	7771	"	
"	Joint Disp (WL Case 5)	DJ	204		7772	7782	"	16 blanks Last Rec.
"	Reactions (WL Case 5)	R	204		7783	7793	"	16 blanks Last Rec.
"	Axial Load (WL Case 5)	AL	200		7794	7803	"	
"	Shears (WL Case 5)	S	200		7804	7813	"	
"	Y Moments (WL Case 5)	YM	200		7814	7823	"	
"	Z Moments (WL Case 5)	ZM	200		7824	7833	"	
"	Joint Disp (WL Case 6)	DJ	204		7834	7844	"	16 blanks Last Rec.
"	Reactions (WL Case 6)	R	204		7845	7855	"	16 blanks Last Rec.
"	Axial Load (WL Case 6)	AL	200		7856	7865	"	
"	Shears (WL Case 6)	S	200		7866	7875	"	
"	Y Moments (WL Case 6)	YM	200		7876	7885	"	
"	Z Moments (WL Case 6)	ZM	200		7886	7895	"	
"	Joint Disp (Ice Load)	DJ	204		7896	7906	"	16 blanks Last Rec.
"	Reactions (Ice Load)	R	204		7907	7917	"	16 blanks Last Rec.

DISK STORAGE OF DATA

PROGRAM	DATA GROUP	VARIABLE NAME	NO OF VAR PER GROUP	WORD NUMBERS	FIRST RECORD NUMBER	LAST RECORD NUMBER	PERM OR TEM.	REMARKS
BRSYS08 DC701	Axial Load (Ice Load)	AL	200		7918	7927	Tem	
"	Shears (Ice Load)	S	200		7928	7937	"	
"	Y Moments (Ice Load)	YM	200		7938	7947	"	
"	Z Moments (Ice Load)	ZM	200		7948	7957	"	
"	Joint Disp (Dead Load)	DJ	204		7958	7968	"	16 blanks Last Rec.
"	Reactions (Dead Load)	R	204		7969	7979	"	16 blanks Last Rec.
"	Axial Load (Dead Load)	AL	200		7980	7989	"	
"	Shears (Dead Load)	S	200		7990	7999	"	
"	Y Moments (Dead Load)	YM	200		8000	8009	"	
"	Z Moments (Dead Load)	ZM	200		8010	8019	"	
"	Joint Disp (WL SP)	DJ	204		8020	8030	"	16 blanks Last Rec.
"	Reactions (WL SP)	R	204		8031	8041	"	16 blanks Last Rec.
"	Axial Load (WL SP)	AL	200		8042	8051	"	
"	Shears (WL SP)	S	200		8052	8061	"	
"	Y Moments (WL SP)	YM	200		8062	8071	"	
"	Z Moments (WL SP)	ZM	200		8072	8081	"	
"	Joint Disp (Pt. Loads)	DJ	204		8082	8092	"	16 blanks Last Rec.
"	Reactions (Pt. Loads)	R	204		8093	8103	"	16 blanks Last Rec.
"	Axial Load (Pt. Loads)	AL	200		8104	8113	"	

DISK STORAGE OF DATA

PROGRAM	DATA GROUP	VARIABLE NAME	NO OF VAR PER GROUP	WORD NUMBERS	FIRST RECORD NUMBER	LAST RECORD NUMBER	PERM OR TEM.	REMARKS
BRSYS08 DC701	Shears (Pt. Loads)	S	200		8114	8123	Tem	
"	Y Moment (Pt. Loads)	YM	200		8124	8133	"	
"	Z Moment (Pt. Loads)	ZM	200		8134	8143	"	
"	Load Gp. 1 DISP.	DJ	204		8144	8154	"	16 blanks Last Rec.
"	Load Gp. 1 REACTIONS	R	204		8155	8165	"	16 blanks Last Rec.
"	Load Gp. 1 AXIAL LOAD	AL	200		8166	8175	"	
"	Load Gp. 1 SHEARS	S	200		8176	8185	"	
"	Load Gp. 1 Y MOMENT	YM	200		8186	8195	"	
"	Load Gp. 1 Z MOMENT	ZM	200		8196	8205	"	
"	Load Gp 2 DISP.	DJ	204		8206	8216	"	16 blanks Last Rec.
"	Load Gp. 2 REACTIONS	R	204		8217	8227	"	16 blanks Last Rec.
"	Load Gp. 2 AXIAL LOAD	AL	200		8228	8237	"	
"	Load Gp. 2 WHEARS	S	200		8238	8247	"	
"	Load Gp. 2 Y MOMENT	YM	200		8248	8257	"	
"	Load Gp. 2 Z MOMENT	ZM	200		8258	8267	"	
"	Load Gp. 3 DISP.	DJ	204		8268	8278	"	16 blanks Last Rec.
"	Load Gp. 3 REACTIONS	R	204		8279	8289	"	16 blanks Last Rec.
"	Load Gp. 3 AXIAL LOAD	AL	200		8290	8299	"	
"	Load Gp. 3 SHEARS	S	200		8300	8309	"	

DISK STORAGE OF DATA

PROGRAM	DATA GROUP	VARIABLE NAME	NO OF VAR PER GROUP	WORD NUMBERS	FIRST RECORD NUMBER	LAST RECORD NUMBER	PERM OR TEM.	REMARKS
BRSYS08 DC701	Load Gp. 3 Y MOMENT	YM	200		8310	8319	Tem	
"	Load Gp. 3 Z MOMENT	ZM	200		8320	8329	"	
"	Max Des DISP.	DJ	204		8330	8340	"	16 blanks Last Rec.
"	Max Des REACTION	R	204		8341	8351	"	16 blanks Last Rec.
"	Max Des AXIAL LOAD	AL	200		8352	8361	"	
"	Max Des SHEAR	S	200		8362	8371	"	
"	Max Des Y MOMENT	YM	200		8372	8381	"	
"	Max Des Z MOMENT	ZM	200		8382	8391	"	
"	Load Cond Max Des DISP	CDJ	204		8392	8402	"	16 blanks Last Rec.
"	Load Cond Max Des REACTIONS	CR	204		8403	8413	"	16 blanks Last Rec.
"	Load Cond Max Des AXIAL LOAD	CAL	200		8414	8423	"	
"	Load Cond Max Des SHEAR	CS	200		8424	8433	"	
"	Load Cond Max Des Y MOMENT	CYM	200		8434	8443	"	
"	Load Cond Max Des Z MOMENT	CZM	200		8444	8453	"	
"	SPANS TO DESIGN	NSD	19	1=sp 1, 2=sp2 etc.	8454	8454	"	1 blank Last Word
"	Max Des 10th Pt Shears	V10	190	1→10=Span 1,11→20= Span 2, etc.	8455	8464	"	10 blanks Last Record
"	Max Des 10th Pt Y MOM	YM10	190		8465	8474	"	10 blanks Last Record
"	Max Des 10th Pt Z MOM	ZM10	190		8475	8484	"	10 blanks Last Record
					8485			

DISK STORAGE OF DATA

PROGRAM	DATA GROUP	VARIABLE NAME	NO OF VAR PER GROUP	WORD NUMBERS	FIRST RECORD NUMBER	LAST RECORD NUMBER	PERM OR TEM.	REMARKS
	Member & Pos With sign panels		(38,2)		8485	8488		
	Load Dead		(38)		8489	8490		
	Load Ice		(38)		8491	8492		
	Load WL #1		38		8493	8494		
	Load WL #2		38		8495	8496		
	Load WL #3		38		8497	8498		
	Load WL #4		38		8499	8500		
	Load WL #5		38		8501	8502		
	Load WL #6		38		8503	8504		
					8505			

DISK STORAGE OF DATA

PROGRAM	DATA GROUP	VARIABLE NAME	NO OF VAR PER GROUP	WORD NUMBERS	FIRST RECORD NUMBER	LAST RECORD NUMBER	PERM OR TEM.	REMARKS
BRSYS02 DC101	Span 1	BFW	(21)	Bottom Flange widths at 20th Pt. on Span	8485			
	Span 1	TFW	(21)	Top Flange width at 20th Pt. on Span				
	Span 1	XSECCD	(21)	Cross Section Codes at 20th Pt. on Span		8488	Tem	17 blanks in last record
"	Span 2	"	"	"	8489	8492	"	"
"	Span 3	"	"	"	8493	8496	"	"
"	Span 4	"	"	"	8497	8500	"	"
"	Span 5	"	"	"	8501	8504	"	"
"	Span 6	"	"	"	8505	8508	"	"
"	Span 7	"	"	"	8509	8512	"	"
"	Span 8	"	"	"	8513	8516	"	"
"	Span 9	"	"	"	8517	8520	"	"
"	Span 10	"	"	"	8521	8524	"	"
"	Span 11	"	"	"	8525	8528	"	"
"	Span 12	"	"	"	8529	8532	"	"
"	Span 13	"	"	"	8533	8536	"	"
"	Span 14	"	"	"	8537	8540	"	"
"	Span 15	"	"	"	8541	8544	"	"
"	Span 16	"	"	"	8545	8548	"	"
"	Span 17	"	"	"	8549	8552	"	"

DISK STORAGE OF DATA

PROGRAM	DATA GROUP	VARIABLE NAME	NO OF VAR PER GROUP	WORD NUMBERS	FIRST RECORD NUMBER	LAST RECORD NUMBER	PERM OR TEM.	REMARKS
DC101	Span 18	XSECCD	(21)	Cross Section Codes at 20th Pt. on Span	8553	8556	Tem	17 blanks in last record
"	Span 19	"	"	"	8557	8560	"	"
BRSYS01 DC001R		C(7),FJT	8	Fictions Member Array for fixed joint	8561	8561	"	12 bks in Rec
BRSYS60 GC001				Store 109 card	8562	8562	"	"
DC001R	Angles of Legs	ANGL	7	1-7	8563	8563		
DC001R	No. of Design Pts.	NOPT	1	1	8564		Perm	
	Design Pt. Array	PT(I)	209 Max	2-210	8564	8574	"	2 Byte Integers

DISK STORAGE OF DATA

PROGRAM	DATA GROUP	VARIABLE NAME	NO OF VAR PER GROUP	WORD NUMBERS	FIRST RECORD NUMBER	LAST RECORD NUMBER	PERM OR TEM.	REMARKS
DC003	Load Type Action Matr	AM(7,7,2)	98		8575	8580		1.1
For other	points record	= 8575 +	(Span#-1) *	55 + (Point#-1) * 5				
DC003	Load Type 2 Action Matr	AM(7,7,2)	98		9620	9625		1.1
For other	points record	= 9620 +	(Span#-1) *	55 + (Point#-1) * 5				
DC003	Load Type 3 Action Matr	AM(7,7,2)	98		10665	10670		1.1
For other	points record	= 10665 +	(Span#-1) *	55 + (Point#-1) * 5				
DC005	Load Factors	LDFCT	96	(8,2,2,3)	11710			
				Truck No. 1=Inv. 2=Opr.				
				1=Pos M. 2=Neg M. Factors		12754		
Record N =	11705 * (Seq. No. * 5)			Seq. No. = Sequence Number in array	@ Rec. 8564			
DC005	Cross Sect. Type	XSECCD (Integer)	1	17 in 5th Record of Group				
DC006	Load Factors Slab	LDFCT	96	Same as DC005	12755			Truck #1

DISK STORAGE OF DATA

PROGRAM	DATA GROUP	VARIABLE NAME	NO OF VAR PER GROUP	WORD NUMBERS	FIRST RECORD NUMBER	LAST RECORD NUMBER	PERM OR TEM.	REMARKS
DC101	Dimensions of Section	EFW T3						
		D4 T4	231	Packed 21 per variable	12756		Perm	
		WS DS						Span #1
		D6 D7						
		AS1 AS2						
		RME						
		Record for	Span N = N * 12 + 12744			12983		
DC001R	Sections	AB(7,10)	70 per span					
	Truck Char-acteristics	LT(I,J) I=Truck	I=1-3 J=1-48		12984		Perm	
		ICR	1	Word 5	12991			Output Control
		WHF	1	Word 6	12991			Wheel Fraction
		PCTIM	1	Word 7	12991			Percent Impact
		TWT1	1	Word 8	12991			Total Weight Truck #1
		TWT2	1	Word 9	12991			Total Weight Truck #2
		TWT3	1	Word 10	12991			Total Weight Truck #3

DISK STORAGE OF DATA

PROGRAM	DATA GROUP	VARIABLE NAME	NO OF VAR PER GROUP	WORD NUMBERS	FIRST RECORD NUMBER	LAST RECORD NUMBER	PERM OR TEM.	REMARKS
DC005	Point Design Data			12 rec/point	12992	13003		Points Packed to front of
				for 209 points	13004	15499		area.
DC005	Point Design Data	Used for LL Run on Composite Only		12 rec/point	15500	15511		Points Packed
				for 209 points	15512	18007		to front of area.
DC005		ADDACT(30,8)		Add Action Array All runs & DL for Comp.	18007	18019		SFACSS(2) last 2 words
DC005		ADDACT(30,8)		Add Action Array LL run for Composite	2 18010	18032		
				~~Point #'s DC005~~	~~18033~~	~~18043~~		
					~~18044~~			

DISK STORAGE OF DATA

PROGRAM	DATA GROUP	VARIABLE NAME	NO OF VAR PER GROUP	WORD NUMBERS	FIRST RECORD NUMBER	LAST RECORD NUMBER	PERM OR TEM.	REMARKS
?	Areas Mxx, Myy, Vzy	A(33,23)	759		17251	17288		Span #1
For other spans beginning record = 17251 + (Span#-1) * 38								
?	Mxx End Mom	EMxx	191	(38 gps)	17289	17298		EM(1.0L)
For left end of span record = 17259 + (Span#) * 20								
For right end of span record = 17269 + (Span#) * 20								
?	Myy End Mom	EMyy	191	(38 gps)	17669	17678		EM(1.0L)
For left end of span record = 17639 + (Span#) * 20								
For right end of span record = 17649 + (Span#) * 20								
?	Vzy End Shears	EVzy	191		18049	18058		EV(1.0L)
For left end of span record = 18019 + (Span#) * 20								
For right end os span record = 18029 + (Span#) * 20								
?	Mxx Static Mom		191	171 groups	18429	18058		1.1
For other points record = 18429 + (Span#-1) * 90 + (Point#-1) * 10								

DISK STORAGE OF DATA

PROGRAM	DATA GROUP	VARIABLE NAME	NO OF VAR PER GROUP	WORD NUMBERS	FIRST RECORD NUMBER	LAST RECORD NUMBER	PERM OR TEM.	REMARKS
?	Myy Static Mom		191	171 groups	20139	20148		1.1
For other	points record	= 20139 +	(Span #-1)	* 90 + (Point#-1) * 10				
?	Vzy Static Shear		191	171 groups	21849	21858		1.1
For other	points record	= 21849 +	(Span #-1)	* 90 + (Point#-1) * 10				
					23559			

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